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THE MINERALOGICAL SOCIETY

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 6th, 1894.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The death of the Rev. George Gordon, of Birnie, Elgin, was announced.

Mr. J. J. Beringer, A.R.S.M., F.I.C., Mr. L. J. Spencer, B.A., and Mr. W. W. Watts, M.A., F.G.S., were elected Members of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 6th, 1894.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Sixteen Members and one visitor were present.

The following papers were read:—

1. A note on the Plas Newydd zeolite: by Alfred Harker, M.A., F.G.S.: with an analysis by L. J. Spencer, B.A.

2. Note on some inclusions in Quartz: by Frank Rutley, F.G.S. (page 285.)

3. Mr. A. E. Tutton, Assoc.R.C.S., F.C.S., described the following instruments:—

α. An instrument for grinding section-plates and prisms of crystals of artificial preparations accurately in the desired directions.

β. An instrument of precision for producing monochromatic light of any desired wave-length in a way useful for the investigation of the optical properties of crystals.

Both instruments were exhibited at the meeting. With the latter instrument, using the lime-light for illumination, Mr. Tutton showed the interference figures of brookite, apophyllite, cæsium sulphate and seignette salt for different simple colours of the spectrum.

Specimens were exhibited in illustration of Mr. Rutley's paper, and the largest specimen known of Cornish Danalite was exhibited by Mr. Miers.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 10th, 1894.

R. H. Scott, Esq., F.R.S., Past President, in the Chair.

Mr. John Gill, F.C.S., Organising Secretary in Technical Instruction, Cornwall County Council, Gwealhallas, Helston; Mr. R. A. Gregg,

Curator of the Museum of the Royal Institution of Cornwall, Truro; and Mr. R. Arthur Thomas, Mining Engineer, Tregerna, Camborne, were elected Members of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 10th, 1894.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Fifteen Members and one visitor were present.

The following papers were read:—

1. On Nantokite: by Prof. A. Liversidge, M.A., F.R.S. (Page 326.)
2. On the Structure-planes of Corundum: by Prof. J. W. Judd, F.R.S.
3. On the chemical analysis of a meteoric stone found at Makariwa, Invercargill, New Zealand: by Mr. L. Fletcher, F.R.S. (Page 287.)

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 19th, 1894.

Dr. Hugo Müller, Vice-President, in the Chair.

The following Members were selected for nomination—Prof. Green, Mr. Harker, Mr. Watts and Mr. Tutton—to replace the four retiring Members of Council—Mr. Gurney, Prof. Liveing, Lieut.-Gen. McMahon and Mr. Teall.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 19th, 1894.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Eleven Members and three visitors were present.

The following papers were read:—

1. A chemical study of some native arseniates and phosphates: by Prof. A. H. Church, M.A., F.R.S.
2. The occurrence of Mispickel in the Stewartry of Kirkcudbright: by P. Dudgeon, Esq.

A new form of goniometer was exhibited by Miss Walter.

On the invitation of the President, Dr. J. E. Talmage gave an account of the occurrence of gigantic crystals of Selenite in Wayne County, Utah.

RECEIPTS.

	£	s.	d.
Balance from year 1892	22	17	1
Subscriptions:—(1) in advance	1	1	0
,, (2) current	56	14	4
,, (3) in arrear	6	6	0
Entrance Fees and Compositions	22	1	0
Sale of Journal	20	19	10
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Authors' extra separate copies	9	6	6
Donations by Lieut.-Gen. C. A. McMahon	8	14	0
	£155	6	11

PAYMENTS.

	£	s.	d.
Printing and Stationery	102	1	0
Illustrations	16	15	0
Attendance at Meetings (1892-3)	2	2	0
Editorial and Clerical Expenses	Nil		
Postage, Parcels, &c.	3	12	5
Insurance of Stock of Journal (1892-3)	2	16	0
Investments and Commission	7	7	2
Bank Commission on Cheques	0	1	6
Cash in Office	0	13	4
Balance in Bank	19	18	6
	£155	6	11

Examined and compared with the vouchers and found correct. (Signed)

January 26th, 1894.

BENEDICT KITTO,
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LIABILITIES.

	£	s.	d.
Printing and Stationery	45	2	6
Illustrations	Nil		
Secretarial Postage	0	6	1
Excess of Assets over Liabilities	275	17	3
	£321	5	10

The number of Life Members on December 31st, 1893, was 35.

ASSETS.

	£	s.	d.
Cash in Office	0	13	4
Balance at the Bank	19	18	6
Subscriptions for 1890-3 unpaid	13	13	0
Stock in 2¾ per cent.: £267 2s. 9d. at 99	264	9	4
Interest on Stock (unpaid)	1	16	9
Sale of Journal:—(1) due from Publishers...	15	14	1
,, ,, (2) due on Office Account	2	1	7
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(Signed)

L. FLETCHER,

General Secretary.

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THE MINERALOGICAL MAGAZINE

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No. 48. SEPTEMBER, 1894. Vol. X.

The Ruby and Sapphire Deposits of Moung Klung, Siam.

By Henry Louis, A.R.S.M., F.I.C., F.G.S., M.A.I.M.E., etc.

[Read June 13th, 1893.]

THE following brief notes on the occurrence of these gems in one of the least known portions of the Siamese ruby fields may prove of nterest, as the particular district to which they refer has very rarely, if ver, been visited before by any European, whilst nothing at all has ever een written on the subject as far as I am aware. The notes are chiefly xt acts from my journal for the months of May and June 1892, which I enture to present with as little modification as possible, in the belief that description written on the spot is likely to give a more correct and vivid, ven although it be a less highly finished picture of the locality than can e attained by any subsequent elaboration.

Moung Klung is a district or sub-province that lies between the two rovinces of Chantabun and Krat, on the western side of the first named. t is administered by a Governor who lives in the small fishing village of an Yao; he is in most respects subject to the Governor of Chantabun, ne latter being a very intelligent man who speaks good English, having erved for some time in the U.S. Navy.

The province of Chantabun proper has long been known as being rich in rubies. The well known explorer Henri Mouhot, writing in 1868, says that "precious stones of good quality are found in the mountains of Chantabun; there is even at the East of the town a hill called the mountain of the Precious Stones; it seems, according to Mgr. Pallegoix (Archbishop of the French Mission at Bangkok) that there was a time when they were very plentiful since he picked up a handful in half an hour, that is to say as much as the inhabitants of the province now find in a year. Another proof of their present extreme rarity is that it is no longer possible to buy any, even at very high prices."

It would seem, accordingly, that up to the date at which this traveller visited Chantabun (1859) there had been no systematic ruby mining; he devotes much attention to the ethnology of the country, and yet amongst all the various races whom he describes as inhabiting this district he makes no mention at all of Burmese, although at present the whole of the gem mining of this country is practically in their hands. I therefore conclude that the Burmese can only have come into the country and commenced their mining operations within the last thirty years, and that the gems previously obtained were picked up by the natives on the surface of the ground, in water courses, shallow streams, &c., without their having carried on any such systematic working for them as they do now.

There is regular steamer communication twice a week between Bangkok and Paknam Chantabun (the mouth of the Chantabun river) by means of small vessels of 100 to 150 tons burden, drawing about 9 feet of water, the journey taking about 18 hours, more or less, according to the season. A curious isolated mass of rock, called from its shape the Lion rock,[1] marks the mouth of the river, whilst a signal station and a small fort occupy a prominent position on the summit of a high red bluff on the western side of the entrance. The Chantabun river is over a mile wide just inside its mouth, which is formed, however, by the confluence of several other rivers. The Chantabun proper is some 300 yards wide, and is very shallow, with flat sandy banks. A fair amount of traffic is carried on in this river by means of well built native boats, and there is even a small steamer which can ascend the river as far as the town of Chantabun at some seasons of the year. The town is a large flourishing place, and forms the market whither most of the native miners bring their gems for sale. There are also large coffee, pepper and rice plantations in the

[1] I subsequently landed on this rock and found it to consist of softish pink and yellow shales dipping southwards; from their appearance I judge them to be of secondary age.

neighbourhood, and a good deal of jungle produce is also brought in, amongst which eagle-wood and various kinds of lac are the most important articles. Nevertheless the staple industry of the place appears to be gem mining, and upon this the bulk of the population, consisting of Siamese, Burmese, Shans, Chinese, Annamites, etc., appear to depend directly or indirectly for their means of livelihood.

From Chantabun there are rough cart roads about 12 miles long leading to Ban Tohi and to Wat Tok Prum, from both of which places bad jungle tracks, say another 7 miles long, traverse practically the entire length of the ruby mining districts of Moung Klung, the centre of which is the small Burmese village of Ban Yat. Another route to this district from Chantabun is by boat, down the Chantabun river and thence through a regular network of creeks up the small stream called the Klong Ven to a small village called Ban Klong, whence a jungle track also leads to Wat Tok Prum. This part of the country is flat and open, the jungle on the river banks consisting mostly of bamboo. On leaving the river the country consists of a series of low undulations sparely wooded except in the hollows, till a small hill range known as Kao Tong, 900 feet above sea level, is reached. The hills here are covered with dense jungle, and, although not very elevated, the character of the country bears a decidedly mountainous aspect, apparently forming the foot hills of the large ranges to the north. Gem mining is confined to the valleys and the sides of these foot hills, and is there actively carried on by a population of some 200 men. The valleys are from 600 to 800 feet above sea level, whilst the hills that separate them are about 500 feet higher. All these valleys are traversed by small mountain streams, affluents of the river Ven, and the narrow patches of alluvial upon the banks of these streams form the gem mining areas, properly so called. In the upper portions of their course, these streams are too rapid to deposit any alluvial, but as the valleys open out a little and the speed of the streams decreases, patches of alluvial form, especially at the bends of the streams, and these patches, which are all of small extent and often very narrow, are the site of the operations of the gem miners.

In addition to the gems occurring in the true alluvial, some are also obtained from the soil covering the lower portions of the flanks of the hills on either side of the stream. These latter deposits, being above flood level, are worked by the natives during the rainy season when the alluvial flats are under water. They are of comparatively small importance, and the others are always worked by preference when accessible. The gemmiferous ground of the hill workings appears to be the result of subaerial

decomposition of the rocks composing the hills, due to the high temperature and excessive rainfall, rather than to fluviatile action such as has produced the alluvial gravel.

The principal, if not the sole, constituent of these hill ranges is a trap rock; this rock, sometimes hard and sometimes decomposed into a soft brown clay, forms everywhere the bed rock upon which the alluvial deposits rest, and this same trap rock may be said to be the only component of the boulders that form the gravel, the base of the latter being a tenacious gray, brown or yellow clay, in all probability the product of the decomposition of the same rock.

The following is a partial analysis of this trap rock, which a severe attack of fever unfortunately prevented me from completing:

Soluble in hydrochloric acid	SiO_2	13·27	29·45
	Al_2O_3	5·29	
	CaO	3·36	
	FeO	4·79	
	MgO, Alkalies	not determined	
Insoluble in hydrochloric acid	SiO_2	50·94	70·55
	Al_2O_3	8·69	
	FeO	1·66	
	CaO	3·99	
	MgO, Alkalies	not determined	

Besides the boulders of trap, most of which are well rounded in the deeper deposits and sub-angular in the shallow ones, a few boulders of white quartz are found, but only very sparingly.

The other minerals present in the gravel are:

Rubies.
Sapphires.
Opaque Corundum.
Quartz, transparent, in good crystals.
Zircon, plentiful.
Ilmenite, very plentiful.
Topaz, very rare.

It is only the first two minerals that possess any commercial value or that are sought for by the Burmese miners. In a number of trial pits which I sank to test the ground, the average proportion of the weight of rubies to that of sapphires was about as 2 to 1: the former are poor in colour, pale and of dull lustre, the latter mostly opaque and dull. The specific gravity of the former I found to be 3·979, and of the latter 3·974

the former being slightly the harder. The opaque corundum may almost be said to pass into sapphire for the most part.

The zircon is of two varieties, one deep red and much rounded, the specific gravity of which I found to be 3·477, whilst the other is pale yellowish red of specific gravity 4·667 ; the latter often occurs in fragments showing faces of the prism and secondary pyramid. Both varieties become colourless on heating.

The general character of the deposit is always more or less the same, although its depth varies in different places ; the overburden consists always of clay, very sandy in the upper portions, but denser in the lower, varying from 2½ to 12 feet in depth, whilst the depth of the pay gravel varies from 10 inches to 5 feet.

The Burmese method of working is very simple ; small parties of three or four men working together sink a pit usually some 4 feet in diameter through the overburden, until the gemmiferous gravel is reached. They then take out the latter in baskets, leaving in place all boulders too large to lift, but scraping carefully all round them down to bed rock, and working into the sides of the pit under the overburden as far as the nature of the ground admits. The gravel is carried in baskets down to the nearest creek, and piled up carefully in a curiously pointed conical heap until the pit is cleaned out, when washing commences. When the overburden is very deep, they use a very rude piece of machinery to hoist up the gravel and any water that they may meet with in working ; it consists simply of a long pole pivoted on a short post driven into the ground. To the upper end of the pole is attached a basket or rough bucket by means of a length of rattan, whilst a big stone to act as a counterpoise is tied to the lower end of the pole. The washing is performed in a kind of pan or sieve made of thin strips of bamboo neatly plaited, and supported by a circular frame of bamboo about 1 inch deep, the diameter being between one and two feet ; the bottom of this pan is very slightly concave, and is nice and smooth. The workman fills it with gravel and agitates it below the surface of the water so as to wash out the clay, and then works it up and down with a kind of jerking motion so as to throw the big stones to the top, and these after a rapid examination are thrown away. The smaller stuff is then worked about by means of a combined "jigging" and "vanning" motion, the pan being held sloping away from the operator. This throws the heavier stuff towards the washer, the lighter being thrown downwards. The heavy stuff is scraped off and put aside in a small cocoanut shell, any especially big gem being picked out. The lighter residue in the pan is then glanced at to see if it contain by accident any valuable stone, and is then

thrown away. The heavy stuff is afterwards examined, picked over, and the gems picked out, sized and sorted. Valuable stones are scarcely ever found in this district, the production, although large, consisting of stones of very poor quality. The entire output, the result of the work of these 200 men, may be put down at between £2,000 and £3,000 per annum in value. The weight produced is perhaps not very far from half a million carats, including of course all the poor and almost worthless stuff. These latter data are, however, derived from statements made by the Burmese miners themselves, and are not therefore to be implicitly relied on.

I nowhere found any of these gems *in situ*, nor have I ever heard of any being so found. Having regard, however, to the fact that their occurrence throughout this district is confined to the streams that descend from hills consisting mainly or entirely of trap rock, that the gravel in which they occur is composed only of clay (a decomposition product of the rock), and of boulders of the same, and rests upon a bed rock of the same material I cannot reasonably doubt but that the trap rock must be the matrix within which these gems were originally formed, nor do I see any valid objection to the adoption of this theory, at any rate as a hypothesis, that requires either further proof or else confutation by subsequent discoveries.

Spangolite.

By H. A. Miers, M.A., F.G.S.

[Read October 24th, 1893.]

In the year 1890 Mr. S. L. Penfield described a new copper mineral, to which he gave the name of Spangolite in honour of Mr. Norman Spang, by whom it was first brought to his notice. Of this beautiful mineral only a single specimen was found, and the exact locality has never been ascertained; it belonged to a man living near Tombstone in Arizona, who had gathered together a collection of minerals within a radius of about 200 miles, and it is described by Mr. Penfield as "a rounded mass of impure cuprite which was mostly covered with hexagonal crystals of Spangolite associated with a few crystals of azurite and some slender prismatic crystals of a copper mineral containing chlorine, probably atacamite."

The Spangolite itself occurs in large hexagonal tables or short prisms of a magnificent deep green colour, as may be seen from a portion of the original specimen presented by Mr. Penfield to the British Museum. A full description of the mineral is to be found in Dana's *System of Mineralogy*, Sixth Edition, p. 919, taken from the original paper by Penfield in the *American Journal of Science*, Vol. XXXIX. p. 370.

In June 1893 I was engaged in company with Mr. Fletcher in making a selection from the fine old collection of minerals (mostly Cornish) belonging to Mr. J. C. Williams, of Caerhays, Cornwall—a portion of which he desired to present to the British Museum. Among the specimens selected was one which presented an unusual appearance; it consisted of granular quartz (slightly gossany), upon both sides of which was a little massive cuprite covered and partly replaced by various green copper minerals; chrysocolla, malachite, liroconite and clinoclase, and a little chessylite. In the midst of these, and upon both sides of the specimen, are groups of brilliant translucent crystals of a deep emerald green colour inclined to indigo; these present the aspect of an acute hexagonal pyramid having the apex truncated by a bright basal plane; they are about $2\frac{1}{2}$ mm. in length and $\frac{3}{4}$ mm. in breadth (see *Nature*, 48 (1893), p. 426).

The examination of a minute group of crystals by Mr Prior and myself showed the mineral to be a hydrated sulphate and chloride of copper and aluminium, insoluble in water but readily soluble in acids.

In these and all other respects it was found to be identical with the Spangolite of Penfield; the mineral belongs to the rhombohedral system; the pyramid angle is 53°7′ (Penfield 53°11½′); it has a perfect basal cleavage; it is uniaxial with strong negative birefringence; the specific gravity determined by suspending a fragment in solution of cadmium borotungstate is 3·07 (Penfield 3·141); the basal plane or a cleavage plate subjected to the action of very dilute acids becomes immediately covered with beautiful etched triangles identical with those described by Penfield.

It will be seen that the only difference between the American and the English specimen is the habit, but the faces present are the same, with the exception that the latter is less rich in forms; closer examination of a crystal isolated from a small group shows that the acute pyramid terminates a combination of two hexagonal prisms, as shown in the accompanying figure; both the prisms and pyramid are striated horizontally.

Information regarding locality which is dubious for the American mineral is totally lacking in the case of the English specimen; but the associated minerals are those characteristic of the mines of the St. Day district, near Redruth, Cornwall, from which, moreover, most of the Williams collection was obtained. The character and appearance of the clinoclase and liroconite leave absolutely no doubt that this is the locality at which the Spangolite must have been found.

The St. Day district formerly produced a number of rare copper minerals, many of which are almost unknown elsewhere. The only locality which presents the same associated minerals is the Tintic district in Utah, more especially the Mammoth mine; among the minerals which occur both at this mine and in the St. Day mines are brochantite, pharmacosiderite, olivenite, cornwallite, chalcophyllite, clinoclase, and possibly erinite; among the St. Day minerals almost the only species which are not recorded from the Mammoth mine are liroconite and the rare sulphato-chloride connellite; further, the resemblance between the associated minerals at the two localities is most striking. Considering the doubtful nature of the evidence, it seems quite possible that the American specimen of Spangolite may have been brought from the Tintic district.

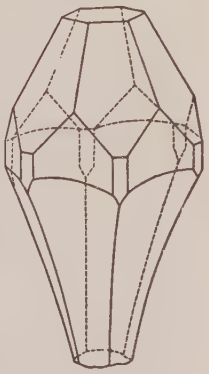
The St. Day mines have been closed for more than 30 years, and m

ndeavour to get information on the spot regarding the exact mine from hich the rare arsenates of copper were raised has been unavailing, in pite of the kind assistance of Mr. Letcher of St. Day. Attempts to nd another specimen of the mineral in any English collection have also een fruitless; all available specimens of connellite in particular were xamined, since the two minerals might be expected to occur together; ut no Spangolite was found.

In August 1893, however, I happened to visit Professor Liebisch at öttingen University, and my attention was then attracted by a small xample of Cornish connellite, which was obtained for the Göttingen useum by Sartorius von Waltershausen in 1868. On this specimen ssociated with connellite are isolated crystals of Spangolite very closely ssembling those described above both in colour and habit; they occur it h the connellite upon a light green scaly arsenate of copper, which verlies a thin coating of chrysocolla upon a matrix consisting of vein uartz and cuprite; there is also chalcophyllite upon the quartz and a ttle stalactitic malachite. Some of the minerals have undergone con- derable change, the connellite having been at one point transformed o a light green and the chalcophyllite into a light brown substance.

This specimen possesses a special interest in the association of the two iphato-chlorides, Spangolite and connellite; they appear to be contem- oraneous, and to have been produced under the same conditions. (See *eues Jahrb. f. Mineralogie*, 1893 (2), p. 174).

On the Göttingen example the Spangolite occurs, t in groups, but in isolated crystals, which have rfectly brilliant terminations and large basal planes, t taper down in an uneven manner towards the ached end. This gives the crystals the peculiar pearance represented in the figure, and the habit once suggests a hemimorphic development; whether e crystals are really hemimorphic could not be cided by goniometric measurement on account of e curved and uneven nature of the attached ends, d it appeared hopeless to search for a pyro- ctric character upon crystals of so small a size, ss than ¾ mm. in length.



The attempt was, however, made by the Kundt process of dusting with mixture of red lead and sulphur, and to my great surprise was perfectly ccessful; the character is so pronounced that the crystals separate red lead and the sulphur in a very marked manner, and may be easily

lifted with the grains adhering. During cooling the crystal becom negatively electrified at the pyramidal unattached end, and positive electrified at the tapering attached end. Both specimens of Corni Spangolite behaved alike in this respect. Simultaneous experimen performed on crystals of connellite of the same size showed no indic tions of pyro-electricity.

Twinning occasionally takes place, as was proved by a crystal from t Göttingen specimen which consisted of two individuals united by the tapering ends in the fashion of an hour-glass. In this crystal the su phur adhered in the form of a ring at the narrowest point where t two individuals meet.

In order to obtain independent evidence of the hemimorphic charact of the mineral, experiments were next made upon the etched figures, being thought that possibly some difference might be found between t etching upon the upper and under surface of a cleavage plate. This w found to be the case; cleavage flakes exposed to the action of dilu hydrochloric acid showed upon both sides the characteristic etched tr angles figured by Penfield; these were identical in form, but very differe in dimensions; the plates were invariably attacked with much great rapidity upon the lower or attached end than upon the surface direct towards the unattached end of the crystal.

Finally, the relation between Spangolite and connellite is a matter considerable interest; the two minerals have a similar composition; th resemble one another in habit, and also in symmetry, although the obse vations of Maskelyne indicate that connellite belongs to the hexagonal typ whereas the etched figures show Spangolite to be rhombohedral. N if the hexagonal pyramid of connellite can be supposed to belong the same vertical series as those of Spangolite, it will be found that i vertical axis would be 1·335 as compared with 2·0108 for Spangolite, *i* exactly $\frac{2}{3}$ of the latter. It is possible, therefore, that there may be additive relation between the two minerals as regards chemical comp sition which affects the length and polarity of the vertical axis.

The composition of Spangolite is established beyond any doubt by t analysis of Penfield, who was able to use three grams of the pure cryst for the purpose, and that the chlorine and alumina are essential is co firmed by their presence in the Cornish specimen.

On the other hand, Penfield's analysis of connellite was made on on 0·074 gram, and can scarcely be regarded as certain.

Although resembling one another in the above respects, the t

minerals may be distinguished with perfect safety by their physical characters. Spangolite has a perfect basal cleavage and negative birefringence, and is pyro-electric; connellite has no basal cleavage, has positive birefringence, and does not exhibit pyro-electricity.

Note on a Zircon from Expailly, Haute Loire.

By Frank Rutley, F.G.S.

[Read October 24th, 1893.]

THE great variation which occurs in the specific gravity of zircon seems to render it possible that the presence of fluid and ga inclusions might, to some extent, account for this. A small, partly red partly colourless crystal was selected from a number of others all derive from the Riou Pezzoliou, Expailly, near Le Puy, which, when examine under the microscope, was found to contain numerous inclusions, som with, others without bubbles.

The crystal weighed 0·155 gram, and its specific gravity was found to b 4·843.[1]

Dana gives 4·863 for a crystal from the same locality, or ·02 more tha the specific gravity of the crystal here described, which shows the commo combination (111), (110). The inclusions lie some little distance benea the surface of the crystal. They are frequently delicate anastomosin tubes, the same tube often varying in diameter, being apparently inflate at one spot and drawn out finely at another. Their length is rude parallel to the principal crystallographic axis. When of very small di meter they sometimes appear perfectly black, owing to total reflection.

The borders of the inclusions are, in some cases, very broad and dar owing to the high refractive index of zircon compared with that of th contents of the cavities. The cavities with very broad dark borders ma contain gas. This seems the more probable since, in the opinion Fouqué and Lévy, zircon results from a process of sublimation rath than from dry fusion. In some cases the cavities appear to be com pletely filled with liquid, but in most cases bubbles are present, whic undergo gradual change in dimensions when the crystal is heated. M bubbles within bubbles, such as occur when liquid and gaseous carbo dioxide are both present in the same cavity, are to be detected under th microscope, and no sudden change is to be noted in any of the inclusio

[1] The pycnometer was used, and, the weather being exceptionally hot, the wa was at a temperature of 79° F.

ien heated to the critical point of carbon dioxide. The liquid inclusions ay, therefore, consist of water only. Glass inclusions may also be esent, especially in those cases where more or less fine dusty matter curs, but the high refractive index of zircon, as pointed out by Rosen-sch, renders any precise determination of the nature of these inclusions ficult.

The almost spongy texture imparted to portions of the crystal by the esence of the minute cavities here described is, I think, sufficient to count for a somewhat lower specific gravity than that met with in other ystals of zircon from the same locality, although it by no means follows at variation in specific gravity can in all cases be referred to the esence of inclusions in this mineral.

On Fulgurites from Griqualand West.

By Frank Rutley, F.G.S.

[Read October 24th, 1893.]

THROUGH the kindness of Professor D. Hahn of the South Africa College, Cape Town, I received, some time since, a series of spec mens of fulgurites which were collected in the vicinity of Griquastad.

In this locality Professor Hahn informs me that there is a particul sand hill which is noted among the farmers living in the neighbourhoo for the frequency with which it is struck by lightning during thunde storms.

The specimens vary from 3½ to 1½ inches in length, and apparent represent widely separated parts of one or more fulgurites.

Lightning tubes formed in sand have been so frequently examined an described that there seems little to add to the literature of this class fulgurite. The treatise by Harting[1] is perhaps one of the most importa contributions, giving, as it does, a good resumé of all that had been pu lished on this subject prior to the year 1874. Subsequently papers b Roemer,[2] Gumbel,[3] Wichmann,[4] Merrill,[5] and Bayley[6] have appeared, a it is in those by the two last named authors that some statements a made which seem to deserve further consideration, especially those beari upon the nature and origin of the superficial corrugations and wing-li projections on lightning tubes.

Among the specimens sent me by Professor Hahn are three whi appear to possess an especial interest. One of these, about 2¼ inch long, ⅜ inch in greatest breadth, and varying in thickness from that of sheet of note paper, in the middle, to rather less than ⅛ inch at the sid consists of two delicate tubes of vitrified sand, which run nearly paral

[1] "Notice sur un cas de formation de Fulgurites et sur la présence d'aut Fulgurites dans le sol de la Néerlande." *Acad. Royale Néerlandaise des Scien* T. XIV. 1874.

[2] *Neues Jahrbuch für Mineralogie*, 1876, p. 33.

[3] *Zeitschr. d. deutschen geol. Gesellsch*, XXXIV. p. 642.

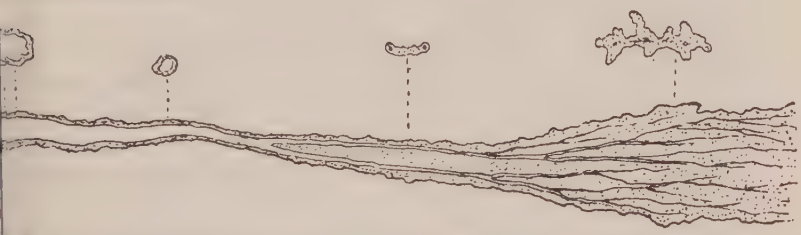
[4] *Zeitschr. d. deutschen geol. Gesellsch*, XXXV. p. 849.

[5] *Proceedings U.S. National Museum*. Vol. IX. p. 83.

[6] *American Journal of Science*. Vol. XLIII. p. 327.

one another and are united by a narrow band of the same glassy terial.

This specimen doubtless represents the continuation of a bifurcated e, and, judging from the small diameters of the tubes, as compared h those of the larger single tubes from the same locality, which range to nearly half an inch, it seems probable that they must have been med at a considerable distance from the point at which the lightning t entered the sand.



The band of vitrified sand which unites them has seemingly originated the same manner as the external wing-like ridges on the larger tubes, I quite agree with the views entertained by Mr. Merrill and Professor ley that such ridges are not caused by a collapse of the tube, as gested by Harting.[1]

With regard to these ridges, Mr. Merrill asks, "Is it not more probable they are formed by the lightning's following out the path of least stance, causing the bore to be enlarged here and contracted there in rdance with the conductibility of those portions through which it sed and the amount of moisture they contained, and that the small ches and wings, sometimes mere points, are lateral offshoots? The lute contact, in some cases, of the inner walls of the wings, together h the fluidal structure extending from within outward, as noted by hmann, would, it seems to me, tend to prove that they are original ctures, and in no way caused by a subsequent collapsing."[2]

Professor W. S. Bayley[3] appears to have arrived at a similar conclusion, speaking of these wing-like processes, he remarks, "Throughout

[1] 'Ces rugosités répondent en partie à autant de plis de la paroi du tube. Ces peuvent être expliqués de deux manières, soit en admettant que l'effet expansif vapeur d'eau n'a pu s'exercer d'une manière égale dans toutes les directions ant le trajet de la foudre, soit en supposant que le tube, d'abord mou au ent de la fusion du sable, a subi une pression extérieure par le sable environ- qui s'écroulait." *Op. cit.* p. 9.

[2] 'On Fulgurites." *Proc. U.S. Nat. Mus.* Vol IX. p. 88.

[3] 'A Fulgurite from Waterville, Maine." *American Journal of Science*, XLIII. p. 328.

their greater extent the wings are merely a single layer of glass, to bot sides of which sand grains adhere in large numbers. The continuity the glass across the corrugations seems to lend credence to the view Merrill that these irregularities on the surface of sand fulgurites are du not to the collapsing of the walls of the tube, as suggested by Wichmann but to the selective power of the electricity in directing its course throug the sand. That the corrugations are original structures due to the actio of the electric current, rather than accidental ones, is also indicated b their spiral twist."

A thin slice taken transversely through the tubes at one end (Fig. Pl. vii.) of the Griquastad specimen (Fig. 3, Pl. vii.) shows under th microscope that, at all events in the plane of section, there is no com munication between the two tubes, the connecting band consisting clear colourless glass, similar to that forming the tubes and containin numerous steam vesicles.

Harting speaks of the occurrence of what he terms much flattene tubes, the interior walls of which almost touch, so that the passage partially obstructed.[1] Furthermore, Merrill describes (to quote his ow words) " small irregularly rounded lumps of fulgurites without the tubul openings, resembling nothing more than as if a ladle of the molten matt had been poured out upon the ground and 'spattered,' as suggested b Mr. Abbott. The largest of these was some 2 cm. broad and 5 to 6 mm in thickness."[2]

Two of the specimens from Griquastad (Figs. 5 and 7, Pl. vii.) corre pond, to some extent, with this description. The largest (Fig. 7) is 8 inches long and 1 inch in greatest breadth. Its thickness averages le than $\frac{1}{16}$ inch, but from both of the broad surfaces irregular ridges proje up to $\frac{1}{4}$ inch in height. At one end of the specimen two small tubes ope out, each large enough to admit a fine wire. The fractured surface see at the other extremity is, so far as can be made out with a pocket len absolutely closed.

A thin section has been made through a smaller but similar specime (Figs. 5 and 6, Pl. vii.) from the same locality. In this an irregul tubular opening is visible, where one of the ridges springs from the surfa of the irregularly crumpled plate. The remainder of the plate, as well the apophyses, seems to consist of vesicular glass, without any origin cavities other than steam vesicles. It would appear, then, that these th platy fragments occur near the extremities of fulgurites. The actu

[1] *Op. cit.*, p. 9.

[2] *Op. cit.*, p. 88.

extremities probably consist of irregularly crumpled or corrugated sheets of vitreous matter in which no tubes exist.

That the irregular rugose plates just described are not portions of the distinctly tubular part of a fulgurite is evident from the fact that they present on none of their larger surfaces the vitreous glaze which characterises the interior surfaces of such tubes, the only vitreous surfaces visible being on the thin fractured ends. That they are not the external ridges or wings of large tubes is equally demonstrable from the fact that no fracture occurs on their long thin edges.

The branching lines in Fig. 8, Pl. vii., are copied from a photograph,[1] made by the spark from an induction coil when the positive pole is brought over the sensitised surface of a glass plate. The plate is perforated by the spark, but a portion of the discharge is dissipated over the resisting surface of the plate.

In addition to the clearly defined branches, delicate streamers of light may be noted in the photograph. These emanate, not only from the margin of the central perforation, but also in a minor degree from the branches themselves.

Assuming that lateral extensions, somewhat similar to those photographed by the electric spark on the sensitised plate, occur at extremely small intervals along the course of a lightning flash when it passes into loose sand, we might represent the distribution of the electric discharge by a succession of photographs, similar to the one already alluded to, impaled upon an irregularly bent wire.[2] The wire would then denote the general direction of the flash, and around this a tube would be formed, the moisture present being converted into steam and the sand displaced and fused by the passage of the lightning.

It seems probable that the inner surface of the fulgurite tube would lie at or near the limit of the finely fibrous fringe proceeding from the centres of the photographs, each of which might be taken to represent the distribution of the lateral portion of the flash about that point in the wire where the latter passed through the photograph. The extremities of the well-defined branches in the lateral extension of the flash would penetrate between sand-grains lying around the tube, and, by fusing those grains, would form the wing-like excrescences which are so characteristic of this class of fulgurite.

The directions of the lateral branches of the flash would probably be

[1] Taken by Mr. Chapman.

[2] The wire passing through the point in each photograph where the sensitised plate had been perforated by the spark.

determined by the contiguity of the larger interspaces between the sand-grains.

Such an hypothesis abolishes the necessity for any theory involving collapse of the tube in order to account for the ridges upon its outer surface. A series of photographs ranged along a wire can necessarily convey but a very crude suggestion of the conditions which influence the formation of a fulgurite of the sand-tube type. The resisting surfaces, along which the lateral extensions of the electric current spread, occur at infinitely small distances, and, in sand, such surfaces would naturally be very irregular.

The border around the margin of Fig. 8, Pl. vii., may be taken as approximately indicating an enlarged transverse section through a lightning tube, the excrescences being formed by the extremities of the branches which constitute the lateral extension of the discharge at any given point.

The bifurcation of lightning-tubes has been noted by Fiedler and by subsequent observers, a small pebble having occasionally been found at the point where the tube forks. Some of the short pieces of tube, such as that shown in Figs. 1 and 2, Pl. vii., from Griquastad, taper to a very marked extent and may represent either a local inflation or a progressive tapering of the tube.

It is noteworthy that the long fulgurite from Drigg in Cumberland, now in the Mineral Department of the British Museum, appears to be of approximately the same gauge throughout its entire length, which, however, does not represent the original length of the fulgurite, which must probably have been some, possibly many, feet longer.[1]

Although the structures described in this paper present no new features, yet the interpretation put upon them may serve to confirm the views already advanced by Mr. Merrill and Professor Bayley. So far, however, as I am aware, no attempt has hitherto been made to account for the irregularly crumpled sheets of vitrified sand which constitute, in all probability, the extremities of fulgurites of the sand-tube type.

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[1] A fulgurite from this locality measured 40 feet in length—G. D. Gibb, *Trans. Geol. Soc.*, Vol. II. 528. Another from Macclesfield extended to a depth of 22 feet—A. H. Green, *Geol. Surv. Memoir on Sheets* 81 N.W. *and* 81 S.W. p. 76.

Note on some Inclusions in Quartz.

By Frank Rutley, F.G.S.

[Read February 6th, 1894.]

N a quartz crystal, slightly over $2\frac{3}{4}$ inches in length, which has been in my possession for many years, and was stated to come from byshire (possibly Castleton), there is a curious white cirrous inclusion ch describes a graceful feather-like curve, and consists of a series of rly parallel lines of colourless and transparent to opaque snow-white ns, which, under the microscope, are seen to be at times well defined mbohedra; but for the most part they present the appearance of rhom-edra which have been more or less eroded, and they are so ranged nes that one rhombohedron lies with one pair of faces slightly above elow the corresponding pair of faces of the succeeding rhombohedron, giving the line a distinctly serrated edge.

he rhombohedra, or at times mere grains of irregular form, range $\frac{1}{110}$ to about $\frac{1}{1000}$ inch in diameter, and occasionally larger opaque e patches of quite irregular form, measuring nearly $\frac{1}{40}$ inch across, present.

hat these rhombohedra and irregular grains represent a carbonate, as calcite or dolomite, there seems no reasonable ground for doubting. quartz crystal in which they occur is so large that we may safely me that it was formed in a cavity or fissure, and, if it came from the ity indicated, that cavity or fissure was in carboniferous limestone or e of the beds of dolomite so common in the carboniferous limestone s of Derbyshire.

king this into consideration, as well as the ragged and partially d appearance of the little rhombohedra, we are, I think, justified in ning that the latter were derived from limestone which was under-disintegration, and that some of the *débris* was taken up by the z crystal during its formation. The linear arrangement of the rhom-dra and grains is, however, less easy to account for. The quartz al itself is evidently composite in structure. Whether the curved ce upon which the particles of the rhombohedral carbonate are

ranged represents a conchoidal fracture upon which a subsequent growt of quartz took place I am not prepared to say, but such a hypothes does not seem improbable.

The other quartz crystal to be described is of much smaller dimension being only about $\frac{3}{4}$-inch in length, and consists of two individuals i parallel grouping. In this there are numerous colourless transparer rhombohedra irregularly distributed through the crystal. They ar sharply developed, and show the usual strong light-absorption of calcit Their dimensions vary from $\frac{1}{50}$ to $\frac{1}{550}$ inch. In one or two instanc their stepped character proves them to be cleavage fragments. Thi however, is not always the case, since in one instance the crystal is combination of the basal planes with the rhombohedron. Evidence erosion is not common in these small crystals, but in one case a rhomb hedron has been very greatly eroded, and appears to have been envelop in the silica while breaking up into a number of much smaller rhomb hedra.

In addition to calcite, this quartz crystal contains beautiful exampl of vermicular aggregates of chlorite (helminthe), and is traversed in directions by delicate hair-like fibres, apparently of asbestos.

Chemical Analysis of the Meteoric Stone found at Makariwa, near Invercargill, New Zealand, in the year 1879.

By L. Fletcher, M.A., F.R.S.,
Keeper of Minerals in the British Museum.

[Read April 10th, 1894.]

AS the preliminary examination of the Makariwa stone had already indicated to Professor Ulrich[1] the presence of mineral constituents having the physical characters of olivine, enstatite, glass, a substance resembling glass, nickel-iron, troilite, magnetite, hydrous oxide of iron, and possibly chromite, the quantitative chemical analysis presented various difficulties, among which may be specially mentioned the fact that one chemical element (iron) enters into the composition of each of the above fine-grained and closely intermingled constituents. This chemical examination I was invited to undertake by Professor J. W. Judd, F.R.S., through whom the two fragments of the stone sent to this country by Professor Ulrich have been generously presented to the British Museum.

A few words relative to the methods which experience has suggested to mineralogical chemists for the solution of this kind of problem will be of service to others who may hereafter be called upon to undertake such an investigation.

Part I.—Methods of Meteoritic Analysis.

2. *Extraction of the nickel-iron.* In the classical research of Mr. Howard Howard[2] on the composition of the stones reported to have fallen at Siena, Wold Cottage, Krakhut and Tabor, respectively, a research which established for the first time not only the close similarity of those stones to each other, but also their difference from any terrestrial rocks then known, the magnet was already (1802) employed for the extraction of the nickel-iron, and hydrochloric acid and nitro-hydrochloric acid for the separation of the residual unattracted powder into different kinds of

[1] *Proc. Roy. Soc.*, 1893, vol. 53, p. 54.
[2] *Phil. Trans. Roy. Soc.*, 1802, p. 168.

material. Some analysts, as for instance Proust (1806) in the examin tion of the Sigena stone, have kept the powdered material under alcol during the magnetic separation; others, as Berzelius (1834) in t examination of the Blansko meteorite, have replaced the alcohol by wat but neither variation has met with favour among chemists owing to t increased liability of the finer particles of the nickel-iron to beco oxidised during the operation. The magnetic method of separation however, far from perfect, for a noteworthy proportion of non-meta material adheres to the extracted nickel-iron.

3. Various attempts have been made by chemists to discover a solv for the nickel-iron which is without effect on the silicate decomposa by hydrochloric acid: and after aqueous solutions of chlorine, iodi and bromine had been in turn rejected, Wöhler suggested the use cupric chloride, though this involved the introduction of a large prop tion of non-volatile foreign matter into the analysis. Later, it was poin out by Rammelsberg (1870) that an excellent substitute for this reagen provided by a solution of mercuric chloride, such as had been alre employed by Boussingault (1868) in his method of isolation of the car of artificial iron; the use of mercuric chloride being advantageous b by reason of the volatility of mercury compounds and because of slightness of its action on the troilite (ferrous sulphide), schreiber (phosphide of iron and nickel), and the silicates of meteoric stones.

4. More recently still (1888), it has been pointed out by Friedh that the action of mercuric chloride on the latter minerals can be further reduced by the addition of ammonium chloride to the sol liquid. He recommends the use of a solution containing 12 grams of double salt ($HgCl_2,2NH_4Cl,2H_2O$) to the litre: the solution being fre prepared, boiled to expel the dissolved air, and used cold. Furthe prevent the formation of insoluble oxychlorides of iron (containing nickel), the action of the mercuric solution is allowed to take place eith a strong flask from which the air has been extracted or in an atmosp of hydrogen.

5. *Separation of the silicates by means of hydrochloric acid.* separation of the silicates from each other by means of hydrochloric is likewise imperfect; it has been demonstrated by various chemists in this operation there is a very appreciable action on the enstatiti gredient of a meteoric stone. However the operation is conducted, of the enstatitic ingredient passes into solution; the only questi

[1] *Sitz. Ak. Berlin*, 1888, p. 345.

how much; the amount depends on the strength of the acid, the temperature, and the length of time during which the action is continued. Unless precautions are taken, the bases of the greater part of the enstatite may pass with those of the olivine into solution, or on the other hand much of the olivine may be left undecomposed among the enstatitic residue; in one case, for example, an experienced mineralogical analyst has suggested that no less than 21 per cent. of undecomposed olivine were still present in the material which remained to him after the action of the acid. Nor is it practicable to attempt to continue the action until there is no longer a noteworthy amount of silicate being decomposed.

6. The most satisfactory results appear to be obtained when (1) the dilute hydrochloric acid has a specific gravity of 1·06; (2) the action is allowed to take place on the water-bath; (3) to last for two hours, and without much variation in the volume of the acting liquid; and (4) is repeated once or twice after decantation of the products of the preceding extraction.

7. *Determination of the silica of the decomposed silicate.* The greater part of the silica of the decomposed silicate remains with, and must be extracted from, the undecomposed residue: this is effected by boiling the residue, while still moist, with a solution of sodium carbonate, to which sometimes caustic soda is added. My former colleague, the late Dr. Flight, showed that there is an appreciable solvent action by caustic soda on the enstatitic residue itself, and discouraged its use: on the other hand, the addition of the caustic soda is intended to secure the complete removal of the liberated silica, while Rammelsberg himself long ago (1848) pointed out that there is already a perceptible solvent action on the residual silicate, even on boiling with a simple solution of sodium carbonate, and attributed it to the presence of undecomposed olivinic silicate. The rest of the silica is obtained by evaporating the hydrochloric acid extract to dryness.

8. *Determination of the troilite, schreibersite and chromite.* If the sulphur be wholly present in combination with iron as troilite (FeS), and the phosphorus wholly in combination with iron and nickel as schreibersite (Fe_2NiP), the proportions of these mineral constituents can be calculated as soon as those of the sulphur and phosphorus have been determined. The chromite being unacted upon by the hydrochloric acid, remains with the enstatitic residue, and can be weighed after removal of the latter by help of hydrofluoric acid or fusion with alkaline carbonates.

9. *Determination of the alkalies.* The alkalies are best determined by direct extraction according to the method invented by the late

Professor Lawrence Smith; namely, ignition with a mixture of calcium carbonate and ammonium chloride. The action of the various reagents on the glass and porcelain vessels during a prolonged general analysis prevents the assignation of much importance to the weights of the alkalies as obtained after successive removal of the other bases, at any rate when the proportion of the alkalies in the original material is small, as in the case of meteoric stones.

10. *General order of procedure.* For such an analysis of a meteoric stone it is thus necessary (1) so to prepare the powdered material that the mixture is practically homogeneous; to use of this mixture (2) a weighed portion (say 0·5 gram) for the determination of the alkalies; (3) another weighed portion (say 1 gram) for the determination of the sulphur and phosphorus, and therefore of the troilite and schreibersite; and (4) another weighed portion (say 2 or more grams) for successive separations with mercuric solution and hydrochloric acid. In this way become known the proportions of the nickel-iron, chromite, troilite and schreibersite, and the proportion and composition of the residual silicate left undecomposed by the hydrochloric acid. Since the schreibersite, though not easily dissolved by acids, is in very small quantity and in a fine state of division, the whole of its iron and nickel will probably pass with the iron of the troilite into the hydrochloric acid extract: after subtraction of these known amounts from the total bases found in that extract, the residual bases must in general belong to the decomposed silicate, of which the silica itself has been isolated in the way above described.

11. *Case of a rusted meteoric stone.* In the case of a rusted meteoric stone, the late Professor von Baumhauer showed that by heating the powder to low redness in a current of hydrogen, the rust might be brought back to the metallic condition and then extracted with mercuric chloride, without involving any noteworthy alteration in the composition of the residual silicates.

12. *Brief sketch of the analysis of the Makariwa stone.* The above will make sufficiently clear the general plan of the following quantitative analysis of the Makariwa stone, which may be briefly summarised as follows:—

It was found advisable to make a preliminary separation by means of a magnet into attracted and unattracted material. Treatment of the attracted material with ammonio-mercuric solution revealed the fact that the proportion of magnetic oxide of iron was too large to be negligible, and indicated the necessity of reducing the rust of the unattracted

material in a current of hydrogen, and of subsequently extracting the reduced metal with mercuric solution: this prevents the unattracted oxide of iron due to rusting of the alloy from passing into the hydrochloric acid extract with the oxide of iron of the silicate decomposed by the acid. Accordingly, after the sulphur and phosphorus of the unattracted material had been determined, mercuric solution was employed both before and after heating the material to low redness in a current of hydrogen, the residual unrusted and rusted nickel-iron being thus separately removed. Analysis of the post-reduction mercuric extract showed that there had been an appreciable action on the silicate portion of the stone during the reduction. Further, it became obvious that the troilite was largely affected by the heating in hydrogen, and that the greater part of the iron of that constituent, and practically all the iron and nickel of the schreibersite, had gone into the mercuric solution. Hence determinations of the sulphur and phosphorus in the mercurialised residue were likewise made, so that the iron and nickel which had passed into the mercuric solution from the affected troilite and schreibersite might be allowed for. The mercurialised residue itself was treated with hydrochloric acid; the acid solution, the sodium carbonate and caustic soda solution, and the undissolved residue itself were then separately analysed. Further, various determinations of the alkalies were made.

Part II.—Experimental Results obtained in the course of the Analysis of the Makariwa Stone.

13. *Preparation of the material for analysis.* A fragment of the stone, available for chemical investigation, presented on one side the deeply rusted yellowish brown exterior mentioned by Professor Ulrich: the other side had apparently been the face of a fissure and likewise showed a certain amount of rust, but more superficially than in the case of the side last mentioned. After this less rusted face had been scraped as clean as practicable, small fragments weighing somewhat over 15 grams were broken by means of a vice from that part of the stone which had been nearest the middle of the meteorite and appeared to be little altered. The fragments having first been crushed in a steel mortar, the whole, in small quantities at a time, was reduced to greater fineness in an agate mortar. During this operation streaks having a metallic lustre soon manifested themselves, while it was obvious that malleable particles were preventing the smooth working of the pestle: only one coarse grain, attracted by the magnet, was separated as interfering with the pulverisation. Thus there was already no doubt that metallic iron was present,

and that it was present almost entirely as particles of extremely small size The whole of the material was again pulverised, and a second metalli grain was separated as interfering with the reduction to powder.

14. As nickel-iron generally occurs in meteoric stones, not only a particles visible to the naked eye, but also as particles of microscopic siz dispersed through the silicates themselves, very fine pulverisation of th material is necessary, whether the nickel-iron is to be mechanically o chemically separated from the other constituents; on the other hand, th presence of malleable metallic particles of appreciable size interferes wit the required reduction of the other constituents to a fine powder. Henc it was decided to make a preliminary separation of the nickel-iron b means of the magnet; and this would seem to be in most cases advisabl for another reason, namely, that a powder containing grains of metalli iron of various sizes cannot be mixed in such a way as to be satisfactoril considered a homogeneous mixture.

15. To diminish the adherence of the magnetic and non-magneti particles to each other, the powder was kept in the oven at a temperatur of 90° C. for some hours. The magnet used for the separation was a ordinary compass-needle; with this the whole material was slowly worke through in small quantities at a time; a tedious operation for which th expenditure of 9 or 10 hours was found to be necessary.

16. When the unattracted material, in small quantities at a time, wa next pulverised in the mortar, there was a sensible crunching beneath th pestle, showing how much the presence of the metallic particles had pre viously interfered with the completeness of the pulverisation. On a secon magnetic separation, for which only 2½ hours were deemed necessary, th amount of material attracted was only about one-tenth that obtained i the first operation. After the next pulverisation the unattracted materi was an impalpable powder.

17. But the separation into magnetic and non-magnetic, was clear incomplete:—the attracted powder doubtless contained some adhere stony matter, the unattracted as certainly still contained some materi like that already removed by the magnetic needle. It was impract cable, however, to push the mechanical separation farther; still, th unattracted material was now in a state of such fine division that it cou at length be regarded as a homogeneous mixture, and treatment wit mercuric solution in the course of the analysis of the unattracted portio showed later (§40) that practically all the nickel-iron had been actual extracted. After transference to weighing tubes and drying at 110°C the attracted material was determined to weigh 0·4791 gram; the una

tracted material, which was reddish-brown in colour, 14·6929 grams; making together 15·1720 grams, available for chemical analysis.

A. *ATTRACTED MATERIAL: TOTAL WEIGHT 0·4791 GRAM.*

18. *Treatment with mercuric solution.* A portion weighing 0·2471 gram (after being dried at 110°C.) was transferred to a small flask, through the stopper of which passed two glass tubes, one of them reaching nearly to the bottom of the vessel. 200cc. of the above-mentioned solution of mercuric ammonium chloride were poured in; and the cold solvent, assisted by frequent shaking, was allowed to act in an atmosphere of hydrogen during two hours. The liquid having been decanted off, filtered, and washed with air-free water containing some mercuric solution, the material was again submitted to the action of a fresh portion of the solvent until the next morning, but without any other agitation than was caused by the slow bubbling of the hydrogen through the liquid. After decantation and filtration, the material was again submitted to the action of a further 100 cc. for three hours with frequent shaking. To ascertain whether solution of nickel-iron was still taking place, the third extract was acidified and the mercury precipitated from the boiling solution by sulphuretted hydrogen: after filtration and evaporation to dryness, the residual ammonium chloride showed an appreciable tinge of yellow. After no fewer than nine further extractions had been made and separately examined, it was seen that the last extract still contained a noteworthy proportion of colouring matter, and that the solvent effect had been virtually constant since the second or third extraction; the slight differences depended, not on the order of the extract, but on the amount of shaking and the length of time during which the action had been allowed to take place. It was clear that one or other constituent of the attracted material was being only slowly dissolved, and that it was practically useless to push the operation farther. It was inferred from subsequent observations mentioned later (§110) that the continued extraction was due to the presence of particles of nickel-iron and metallic nickel partially protected from the mercuric solution by adherent rust (oxide of iron), which was itself quite unaffected by the solvent.

(a). *Attracted material: mercuric extract (or portion dissolved by the mercuric solution).*

19. *Sulphuretted hydrogen precipitates.* All the sulphuretted hydrogen precipitates were dried and slowly ignited in a large porcelain crucible to get rid of the mercury; there was a small brown residue completely

soluble in nitro-hydrochloric acid. After expulsion of the nitric acid by evaporation to dryness with hydrochloric acid, the residual salt was re-dissolved in water slightly acidified with hydrochloric acid: sulphuretted hydrogen sent down from this solution an immediate dark precipitate: an examination of the filtrate showed that no iron had been carried down with the mercuric sulphide. The precipitate itself, after ignition in a porcelain crucible, was readily soluble in hydrochloric acid, the solution having a distinctly yellow colour: on evaporation to dryness and solution in water, a deep blue colouration was produced by ammonia, showing the presence of copper. The ammonium chloride was decomposed by evaporation with nitric acid, and the copper was afterwards precipitated by caustic soda; the ignited precipitate was oxidised with a drop of nitric acid, again ignited and weighed; the CuO thus obtained was found to weigh 0·0003 gram. As remarked by the late Professor Lawrence Smith, copper is always found in meteoric iron when carefully looked for.

20. *Sulphuretted hydrogen filtrates.* To find the average amount of the solvent action during the later stages, the first seven and the last five extracts (from which the mercury and copper had been thus removed) were severally collected together, and the two solutions were analysed separately in the following way. After the trace of sulphur had been filtered off, nitric acid was added and the solution was evaporated down on the water-bath until the beginning of the ebullition of nitrous oxide through the decomposition of the ammonium chloride: the liquid was then covered with a funnel and further heated until the ebullition had ceased: the funnel being then removed, the evaporation was continued to dryness and the nitric expelled by means of hydrochloric acid. After solution in slightly acidified water and dilution to the volume of a litre, the iron was precipitated in the usual way (after addition of sodium carbonate and acetic acid) by sodium acetate, filtered hot, and immediately washed with boiling water containing a little of that reagent: the precipitate was dissolved in hydrochloric acid and the iron re-precipitated in the same way: finally, after being once more dissolved, the iron was precipitated by ammonia and washed until free from chloride with boiling water containing a little ammonium acetate: this last wash-water was found to be quite free from both nickel and iron. After ignition of the precipitate, the greater part was reduced in hydrogen and dissolved in hydrochloric acid to determine the trace of admixed silica due to the action of the large volumes of hot diluted liquid on the containing vessels. The filtrates from the precipitations of the iron with sodium acetate were evaporated to dryness and a trace of silica removed: the nickel and cobalt were pre-

cipitated with the usual precautions by caustic soda, the nickel and cobalt being converted into higher oxides by bromine for the sake of greater facility of washing: the precipitate was weighed both before and after reduction in hydrogen: it may have contained a trace of magnesia due to the action of the mercuric solution on a minute amount of adherent silicate.

21. The following numbers were obtained:—

Extracts 1—7: Fe_2O_3—0·1666 gram.

After reduction, solution and reoxidation, only a minute precipitate of phospho-molybdate was obtained with molybdic solution: this was not weighed but on direct comparison was estimated to be about $\frac{1}{8}$th the corresponding precipitate obtained from 1·0693 gram of the unattracted material (§37), and three or four times the precipitate obtained from the mercurialised residue of the attracted material (§30): hence the greater part of the schreibersite of the attracted material has passed into the mercuric solution.

(Ni, Co)O—0·0308 gram.

0·0254 gram of this oxide gave on reduction 0·0192 gram (calculated 0·0200 gram), and after separation of the cobalt in the usual way by potassium nitrite, 0·0106 gram of potassium cobalt sulphate ($2CoSO_4$, $3K_2SO_4$) corresponding to 0·0015 gram of cobalt. Hence the nickel and cobalt are in the proportion to each other of 12 : 1.

The filtrate from the cobalt was tested for manganese which was found to be absent.

22. Extracts 8-12. Fe_2O_3 —0·0032 gram.

(Ni, Co)O —0·0024 gram.

The colour of the extracts had already indicated the increased proportion of nickel.

(b). *Attracted material: mercurialised residue (or portion undissolved by the mercuric solution).*

23. The insoluble matter left on the filter contained, in addition to that portion of the original attracted material which had not been dissolved, mercurous chloride, free mercury, and also some adherent mercuric ammonium chloride: after drying, as much as possible was transferred to a weighed porcelain boat.

24. *1. Matter which still adhered to the filter.* The filter, with its adherent matter, was slowly carbonised and ignited, the latter both before and after the addition of a drop of nitric acid.

The weight of the ignited matter was 0·0307 gram.

25. *2. Contents of the boat.* For the removal of the foreign matter,

the boat and contents were heated in a glass tube in a current of hydrogen for half-an-hour, the temperature of the oven itself being 280° C.: after the first heating the material weighed 0·0781 gram, and was a black coke-like substance, strongly attracted by the magnet.

26. The weight only became constant after six more heatings, in some of which the temperature was raised until the mercury in the oven-thermometer began to boil, and the time of heating was prolonged to 1¼ hours: the final weight was 0·0705 gram.

27. The substance was then transferred to a porcelain dish, covered with water, and treated with nitro-hydrochloric acid with the intention of converting any admixed phosphide into phosphate: there was an immediate effervescence, however, which suggested the presence of metal, either through reduction during the heating in the hydrogen even at the above low temperature, or through the incompleteness of the action of the mercuric solution: probably, as already mentioned, particles of nickel-iron and nickel had hitherto been partially protected from the mercuric solution by adherent rust. After evaporation to dryness and a twofold repetition of the evaporation with hydrochloric acid, there was still an insoluble residue of a darkish grey colour.

28. (α). From this some admixed liberated silica was extracted by a solution of sodium carbonate to which some caustic soda had been added, and was found to weigh 0·0036 gram.

29. (β). The small gritty insoluble residue itself weighed 0·0063 gram after ignition.

30. (γ). From the hydrochloric acid solution were obtained

(a) Fe_2O_3—0·0400 gram: after reduction, solution and oxidation, molybdic solution was added; the slightness of the precipitate as compared with the one already mentioned, indicated that the greater part of the schreibersite had passed into the mercuric solution.

(b.) (Ni, Co)O—0·0270 gram: on reduction 0·0108 gram of this oxide yielded 0·0086 gram, and the solution, after removal of the nickel by ammonium sulphide, contained some calcium, possibly, however, introduced by the action of the ammoniacal salts on the glass and porcelain vessels during the removal of the nickel.

B. *UNATTRACTED MATERIAL: TOTAL WEIGHT* 14·6929 *GRAMS.*

1. Extractions with water, alcohol and ether; residual alkalies.

31. (a) *Extracted by water.* 0·9368 gram was boiled with 100cc. of distilled water, filtered after standing three hours, and washed; the

rate, being slightly turbid, was allowed to stand, and after a percepti- settling during the night was again filtered; after standing two more rs, the filtrate, which had now a volume of 250cc., was still slightly, and parently permanently, opalescent. The filtrate was neutral to litmus paper. evaporation to dryness, the residue, including therefore the material ch had been in suspension, weighed 0·0068 gram; this was treated h boiling water which was allowed to stand over it for a time. The soluble part adhered to the dish and weighed 0·0018 gram; it dis- ved speedily in hydrochloric acid, and was found to contain silica, iron, cium, and magnesium; this was probably the matter which had origi- ly been in a state of suspension and had caused the opalescence.

The soluble part was found to weigh 0·0050 gram; it gave a bright low colour to the Bunsen flame; the spectrum, obtained with a small ect-vision spectroscope, consisted of a brilliant sodium line and per- s a faint calcium line. Spontaneously evaporated on a watch-glass, solution gave not only crystals simple, twinned and aggregated, all of m similar to those of gypsum, but also other less definite crystallisa- s; the above crystals were not readily soluble in water, but slowly solved when the watch-glass was kept for some time on the heated n. The solution gave the reactions for both sulphate and chloride, also for calcium and magnesium (in addition to the sodium already tioned).

332. The salts in the aqueous solution may have been due to a speedy ion of the boiling distilled water on the silicates of the meteorite in the sence of a sulphate (the latter due to alteration of some of the troilite), to a similar action which may have taken place, though more slowly, ile the stone was embedded in the ground.

333. (*b.*) *Extracted by alcohol.* The residue from which the part uble in water had been extracted was dried, agitated with 80cc. of solute alcohol, and allowed to stand for 24 hours; the alcohol was n decanted off and a further quantity poured on to the material and canted; the mixed extracts were allowed to stand in a covered beaker three days without any appreciable deposit of insoluble material being med. After decantation, the liquid was allowed to spontaneously aporate; the drying having been completed on the water-bath, the resi- e which was only doubtfully visible was found to weigh 0·0013 gram. is residue having been treated with alcohol once more, 0·0005 gram of s soluble matter adhered to the dish; the alcoholic solution was trans- red to a watch-glass and was seen to have a slightly yellow tinge.

Alcohol thus extracts nothing appreciable from the powder.

34. (*c.*) *Extracted by ether.* The residue from the alcoholic extrac tion was next agitated with 80cc. of ether; the ethereal extract yielded o evaporation only a faint spot of oil-like matter, which dried very slowl on the water-bath; the residue weighed 0·0011 gram, but when treate with ether, as much as 0·0007 gram still adhered to the dish.

Hence ether is likewise without appreciable action on the constituent of the stone.

35. (*d.*) *Residual alkalies.* The amounts of the alkalies still remain ing in the material after the extractions by means of water, alcohol and ether were determined (§73).

2. Unattracted material: determination of the sulphur and phosphorus

36. *Sulphur.* A portion of the material weighing 1·0693 gram wa covered with water and treated with nitro-hydrochloric acid, in sma quantities at a time, on the water-bath: it was evaporated to dryness again treated with nitro-hydrochloric acid, and the evaporation to drynes repeated: after expulsion of the nitric by hydrochloric acid, the residu was extracted with water to which a little hydrochloric acid had bee added; to the filtrate was added ammonia until there was a permanen precipitate, then hydrochloric acid till the precipitate was again dissolved The sulphuric acid was next precipitated by barium chloride; after purifi cation the barium sulphate weighed 0·1730 gram.

37. *Phosphorus.* From the filtrate from the barium sulphate a grea part of the iron was first removed by the method recommended by Professo Lawrence Smith—that is, nine-tenths of the acid solution were reduce by ammonium sulphite, boiled in a platinum dish until there was n longer any smell of sulphurous acid, ammonia added until there was precipitate, then acetic acid, next the remaining tenth of the solution, an finally ammonium acetate; after being boiled for half-an-hour, the liqui was filtered: the filtrate gave no evidence of phosphorus when oxidise and tested with molybdic solution. The precipitate, which thus contain all the phosphorus and is admixed with barium sulphate, was treate with hydrochloric acid, filtered and evaporated to dryness; the residu was dissolved in a little nitric acid: ammonia was added drop by dro until the appearance of a permanent precipitate, then nitric acid until th precipitate was re-dissolved: next molybdic solution and solution o ammonium nitrate until there was 15 per cent. of the latter salt prese in the liquid. The solution was heated to 80° C. and allowed to stan for 3½ hours, when the precipitate was collected and washed wit ammonium nitrate solution: no phosphorus could be detected in th

rate. Finally, the precipitate was dissolved in ammonia and precipi. ed by magnesia mixture: the magnesium pyrophosphate weighed 0038 gram.

3. Unattracted material: determination of the alkalies.

38. Two determinations were made and are mentioned later (§§ 65,).

4. Unattracted material: determination of the chromite.

39. To ascertain whether or not any diamond was present, 1·1885 gram the unattracted material was decomposed with hydrofluoric and sul- uric acids: the residue was entirely opaque, and when examined under microscope appeared homogeneous: it consisted wholly of chromite, l weighed (1) on the filter 0·0041 gram, (2) after ignition 0·0034 gram.

Unattracted material: mercuric extract (or part dissolved by mercuric solution).

40. (*a.*) *Before reduction in a current of hydrogen.* 5·6880 grams the unattracted material were submitted to the action of cold mercuric ution in a current of hydrogen for three hours: after removal of the rcury from the solution in the way already described, the extracted tter was found to be small.

In a second treatment the solvent, assisted by frequent shaking, was wed to act for an hour, and then quietly during the night: the matter racted was not more than $\frac{1}{10}$th of that obtained in the previous opera- n, and did not exceed that obtained in the later stages of the action on attracted material (§ 18): its green colour indicated that it consisted efly of nickel.

The next residue, resulting from a third treatment of the material ending over four hours, was quite white. After slow ignition of the rcuric sulphide precipitates and solution of the small residue thus ained, the filtrate from the slight precipitate produced in this solution sulphuretted hydrogen was added to the collected extracts.

On analysis they yielded :—

O_2— 0·0003 gram (thus showing the slightness of the action of the mercuric solution on the silicates).

O_3—0·0007 gram (indicating the smallness of the amount of un- attracted nickel-iron).

(Ni,Co,Ca,Mg)O — 0·0076 gram: after reduction in hydrogen this ghed 0·0060 gram, and yielded CaO — 0·0011 gram, and $Mg_2P_2O_7$ 0·0047 gram: the latter corresponds to MgO—0·0017 gram; the

(NiCo)O thus amounts to 0·0048 gram and corresponds to 0·0038 gra of metal.

The filtrate from the nickel precipitate obtained with NaHO also yield CaO — 0·0028 gram. The total CaO is thus 0·0039 gram.

41. (*b.*) *After reduction in a current of hydrogen.* (1.) T material, from which iron or nickel could no longer be extracted by mea of the mercuric solution, was now transferred to a platinum boat a heated in a platinum tube to low redness for one hour in a current hydrogen in which it was then allowed to cool. Its colour had n changed from reddish brown to dark grey. It was next subjected in t same way as before for two hours to the action of mercuric solutio after removal of the mercury, the colour of the residue after evaporati to dryness showed that a very considerable action had taken place.

The operation was repeated several times, and each time the extract w much too large to be negligible :—

(2)	low redness for 30 minutes :			mercuric solution for 2 hours.		
(3)	,,	,,	,,	,,	,,	all night.
(4)	,,	75	,,	,,	,,	,,
(5)	,,	90	,,	,,	,,	,,
(6)	,,	105	,,	,,	,,	,,
(7)	,,	135	,,	,,	,,	,,

As the extracts after the first were more or less the same in quantity, seemed that the presence of the silicates was hindering the access of t hydrogen to the material to be reduced, and that only the superfici material was being affected.

(8). The whole material was next heated by seven instalments in t hydrogen current ; and the mercuric solution was allowed to act for tw days : there was a distinct diminution in the amount of iron which pass into solution.

(9). The material was heated by six instalments in the hydrogen a then again as a whole, while the action of the mercuric solution was co tinued for two days : the extracted iron was now larger than the avera of those previously obtained.

(10). The material was again heated in instalments, and was twi treated with mercuric solution : it was ascertained that practically t whole of the reduced metal had been dissolved during the first treatmer

(11). The material was again heated in ten instalments and extract twice by mercuric solution ; in each case a residue was obtained whi showed a negligible action, regard being had to the constant resid obtained in the later stages of the similar treatment of the attract material.

22. During the heating in the platinum tube, the issuing gas was wed to bubble through water which served to retain the expelled mer- y and its chlorides. It was remarked that in operations 2-9, the orbing water turned brown and afterwards gave a brownish-black cipitate: this was clearly due to the formation of sulphuretted hydrogen ng the passage of the hydrogen over the heated material and to the sequent precipitation of the mercury, and it indicated a considerable ration of the troilite (ferrous sulphide): after the ninth operation the olouration and subsequent precipitation were no longer observed. s suggests that the protracted character of the extraction is due to the ual alteration of the troilite. In most of the extracts as obtained r evaporation there was visible some white non-volatile powder, gesting the presence of magnesia and therefore an action on the sili- s during this operation.

23. The precipitates of mercuric sulphide were slowly ignited as before, residue dissolved and again precipitated by sulphuretted hydrogen: small precipitate was found to be copper sulphide, and appeared to be ut the same in amount as the corresponding one obtained from the 471 gram of attracted material (§19): it was not weighed: the filtrate, h would contain any iron carried down with the voluminous precipitates mercuric sulphide, was added to the collected extracts.

d. On analysis the following numbers were obtained:—

$_2$ —0·0054 gram (thus confirming the suspected action on the silicates)

O_3—0·5138 gram.

Ni,Co)O—0·0382 gram: after reduction in hydrogen 0·0297 gram: calculated metal from the oxide is 0·0300 gram. This gave 0·0370 m of potassium cobalt sulphate ($2CoSO_4,3K_2SO_4$), which corresponds to 053 gram of cobalt: hence the nickel and cobalt are in the proportion 1·7 : 1.

The filtrate from the nickel which had been separated by means of eated action of ammonium sulphide yielded at this point, on again ng evaporated to dryness, as much as 0·0260 gram of SiO_2, which st be due to the action on the vessels during the separation.]

—0·0135 gram (part of which must likewise be due to the vessels).

P_2O_7—0·0136 gram, corresponding to MgO—0·0049 gram.

Unattracted material: *mercurialised residue (or part undissolved by mercuric solution).*

25. In such a series of operations as has just been described, it was r that it was impossible to obtain with any approach to accuracy the

whole of the material which had been left unacted upon by the mercur solution: accordingly the part adhering to the filter was not ignited ar weighed. After the above removal of the mercury and its chlorides fro the available residue, it was found that there remained 4·6037 grams mercurialised material for examination.

46. (a.) *Sulphur and phosphorus.* Proceeding in the same way before, it was found that 0·7671 gram of the mercurialised residue yield only 0·0013 gram of barium sulphate and only a trace of phospho-moly date: the iron and nickel of nearly the whole of the troilite and schr bersite have thus passed into the mercuric solution.

47. (b.) *Alkalies.* These were determined as mentioned later (§7

48. (c.) *Treatment with hydrochloric acid.* (a.) 2·5748 grams the mercurialised residue were treated with hydrochloric acid of speci gravity 1·06 for two hours on the water bath, water being occasiona added to replace that lost by evaporation. It was then diluted with bo ing water and allowed to settle, after which the supernatant liquid w decanted off. This treatment was repeated twice. On the occasion the third treatment, the insoluble material was washed by decan'ati several times.

49. The extracts which contain suspended silica were filtered af settling during the night: they filtered with extreme slowness, howev and it would really have been advantageous to have evaporated to dryn before the filtration. This had been avoided because of the proba action of the acid, during evaporation to dryness, on the small amoun the finely divided enstatitic silicate which may possibly be present i state of suspension.

50. On evaporation of the filtered solution to dryness, a small amo of silica was obtained. The other silica, still moist and admixed with material which had not been decomposed by the hydrochloric acid, extracted therefrom by boiling with a strong solution of sodium carbon containing some caustic soda: after dilution with hot water and filtra on a weighed filter, the solvent operation was repeated on the resi The practical difficulty was that at the end of the washing, which quired to be as complete as possible, the insoluble finely divided resi began to pass through the pores of the filter: the residue was accordi now transferred as far as possible to a platinum dish; that part of material which could not be removed from the filter by washing weighed both before ignition (0·0826 gram) and afterwards (0·0817 gra

51. The contents of the dish were boiled with distilled water and allo to stand all night. As the supernatant liquid was slightly opalescent,

ained so after filtration, the liquid was decanted off and the residual erial transferred to a small platinum dish, dried and weighed; this was 1·0292 gram.

2. The decanted slightly opalescent liquid was evaporated to dryness r acidification. As the dark brown colour indicated that the residue isted chiefly of undissolved silicate, the latter was boiled with the um carbonate and caustic soda mixture, which extracted only a trace, ny, of silica: this was added to the main silica and the filtrate was ed to the main solution: the weight of the residual material after tion was 0·0121 gram. The total silica obtained was 0·5932 gram.

3. (β.) The iron, calcium and magnesium which had passed into sodium carbonate and caustic soda solution were likewise determined: weights found being:—

$Fe_2O_3 - 0{\cdot}0083$ gram, $CaO - 0{\cdot}0029$ gram, $Mg_2P_2O_7 - 0{\cdot}0031$ gram.

The corresponding bases may have passed into the solution either g to the imperfect washing of the mixed silica and undecomposed ate or (which is more probable) to the action of the boiling caustic a and sodium carbonate on the latter.

4. (γ.) The bases present in the hydrochloric acid extract were rmined by the usual methods. As it was desired for the sake of comon with results obtained in a direct examination to weigh the alkalies ent at the end of the analysis, the iron and aluminium were precipid by ammonium acetate, the precipitation in dilute solution being ated and then followed by cautious precipitation with ammonia.

5. After solution of the iron and aluminium precipitate in hydroric acid, the separation of the iron from the aluminium was effected the caustic soda method: the solution of the bases being poured into ng solution of caustic soda and boiled for some minutes. This hod, though simpler than the Deville-Cooke method used later, does appear to be entirely satisfactory, when the proportion of the alumina o small as is here the case: the alumina thus obtained is not comely free from iron.

6. The manganese was separated and weighed as sulphide, and a ll quantity of nickel was isolated. After removal of the calcium by a ble precipitation with ammonium oxalate, the magnesium was precipid, after a preliminary expulsion of the ammonium salts, by ammonia ammonium carbonate.

7. During the analysis the first filtrates, which should contain practically whole of the alkalies originally present in the decomposed material, e kept apart from the remaining filtrates and washings, any alkalies

found in which must virtually be wholly due to the action of the liqui on the vessels : as it seemed likely that the alkalies may be at least pa tially present in solution as sulphates, they were weighed as first obtaine then converted completely into sulphates and again weighed ; they we afterwards separated by Finkener's method, *i.e.* precipitated together b means of platinum chloride, rinsed, then washed with a mixture consis ing of two parts of alcohol and one of ether ; the sodium sulphate r moved by washing with ammonium chloride solution ; the residu K_2PtCl_6 decomposed by heating in a current of hydrogen at a temperatu of 246° C., and the potassium chloride extracted with water.

58. The following numbers were obtained :—

Fe_2O_3	...	...	0·3532 gram	0·3540 gram
Fe_2O_3	...	...	0·0008 ,,	
Al_2O_3	...	...	0·0024 ,,	
MnS	...	...	0·0052 ,,	
NiO (CoO)	...	...	0·0005 ,,	
CaO	...	...	0·0078 ,,	
MgO	...	...	0·5089 ,,	

59. Alkalies from first filtrates : mixed salts before and after trea ment with sulphuric acid, 0·0155 gram and 0·0159 gram respectively potassium chloride 0·0013 gram.

60. Alkalies from subsequent filtrates : mixed salts before and aft treatment with sulphuric acid, 0·0047 gram and 0·0047 gram respe tively ; potassium chloride 0·0009 gram.

61. An indirect but more satisfactory determination of the alkalies the part extracted by hydrochloric acid is given later (§ 86) : it is final inferred that even the alkalies of the first filtrates are wholly due to acti of the liquids upon the glass or porcelain vessels.

7. *Unattracted material : the residue after treatment with mercuric solution and hydrochloric acid.*

62. (*a.*) The alkalies were determined by direct extraction (see § 7

63. (*b.*) 0·5115 gram was fused with a mixture of potassium a sodium carbonates : the silica was isolated and the residual insolub material (chromite) was weighed : the iron and aluminium having be precipitated together by sodium acetate twice and then cautiously ammonia, and weighed together, the mixed oxides were treated by t Deville-Cooke method—that is, first heated in a platinum boat in a pla num tube in a current of hydrogen for half-an-hour by means of a Buns flame, and then for ten minutes in a current of dry hydrochloric ac

means of a table-blowpipe—the operation being repeated until the iron had been completely removed and the boat and contents had attained to a constant weight: the alumina and silica were then separated by fusion with sodium bisulphate. This method has the advantage of showing by the colour of the residue whether any of the chromite has been decomposed by fusion with the alkaline carbonates. In this instance, when the operation no longer produced any change of weight, the residue was white and contained no chromium: but during the earlier stages the residue had a green tinge, and doubtless some chromium was often present and was expelled with the iron (§ 72): this was owing to the incomplete pulverisation of the mixed oxides: for, to prevent the introduction of silica during pulverisation in an agate mortar, the mixed oxides had been merely crushed in a steel mortar: this imperfectness of pulverisation made it necessary to heat no fewer than fourteen times in the hydrogen and hydrochloric acid before the iron was completely expelled: under such circumstances the chromium is likewise carried away.

64. The following numbers were obtained:—

Chromite	...	...	0·0028 gram
SiO_2	...	...	0·2769 ,,
Fe_2O_3 (Cr_2O_3)	...	...	0·0943 ,,
Al_2O_3	...	...	0·0011 ,,
MnS	...	...	0·0025 ,,
CaO	...	...	0·0203 ,,
MgO	...	...	0·0004 ,,
$Mg_2P_2O_7$	...	...	0·3241 ,,

8. Alkalies.

65. Various determinations of the alkalies in the unattracted material and its products were made by the method of ignition with calcium carbonate and ammonium chloride.

Proceeding in the way described by the late Professor Lawrence Smith (except that the last portion of the lime was removed by means of ammonium oxalate) 0·5851 gram of the unattracted material yielded 0·0130 gram of the mixed sodium and potassium salts, and these, when treated as if they were wholly chlorides, in turn gave 0·0028 gram of K_2PtCl_6 besides 0·0014 gram of platinum.

66. Examination with the spectroscope showed that lithium was present.

67. As the percentage of alkalies in the unattracted material is therefore small, and it seemed likely that the mixed alkaline salts were partly

sulphates and partly chlorides, (1) a re-determination of the alkalies in the unattracted material was made, the alkaline salts being weighed both before and after evaporation with sulphuric acid: the amounts of the alkalies were also determined (2) in the mercurialised residue, (3) in the residue undissolved by the hydrochloric acid, and (4) in the material which had been treated with water, alcohol and ether. To secure uniformity both of treatment and reagents, all the weighed quantities were severally mixed with appropriate quantities of calcium carbonate and ammonium chloride before the first ignition was begun: further, a mixture of the same amount of calcium carbonate (4 grams) and ammonium chloride (0·5 gram) was prepared for a blank experiment.

68. The ignitions and extractions having been performed in immediate succession in the same way with the same reagents, it was seen that the blank experiment yielded a very appreciable quantity of alkaline salt: this extract (in the form in which it presented itself after the expulsion of the ammonium oxalate and other salts and before treatment with hydrochloric acid) weighed 0·0040 gram, and on examination was found to be essentially sodium carbonate. This alkali was traced to the calcium carbonate itself, and as that reagent had been already mixed with the various residues it became necessary to carefully determine the amount of alkalies yielded by a blank experiment.

69. The stock of calcium carbonate in use being now nearly exhausted two blank experiments were made, in each of which only 3 grams of calcium carbonate and 0·375 gram of ammonium chloride were used.

(α). The first yielded:—mixed alkaline salts, before and after evaporation with sulphuric acid, 0·0040 gram and 0·0041 gram respectively potassium chloride 0·0005 gram.

(β). The second yielded:—mixed alkaline salts, before and after evaporation with sulphuric acid, 0·0040 gram and 0·0045 gram respectively potassium chloride 0·0006 gram.

For 4 grams of the calcium carbonate and 0·5 gram of the ammonium chloride the mean result is:—mixed alkaline salts, before and after evaporation with the sulphuric acid, 0·0053 gram and 0·0057 gram respectively, potassium chloride 0·0007 gram.

70. (1.) 0·4965 gram of the unattracted material gave:—mixed alkaline salts, before and after evaporation with sulphuric acid, 0·0125 gram and 0·0139 gram respectively, potassium chloride 0·0016 gram.

71. (2.) 0·5001 gram of the mercurialised residue gave:—mixed alkaline salts, before and after evaporation with sulphuric acid, 0·0092 gram and 0·0123 gram respectively, potassium chloride 0·0014 gram.

72. (3.) 0·5014 gram of the residue undissolved by hydrochloric acid gave:—mixed alkaline salts, before and after evaporation with sulphuric acid, 0·0164 gram and 0·0202 gram respectively, potassium chloride 0·0019 gram.

In this experiment, the alkaline extract as at first obtained contained some chromate clearly due to the decomposition of chromite: after reduction by evaporation with alcohol and hydrochloric acid, and precipitation with ammonia, the Cr_2O_3 was determined to weigh 0·0009 gram.

A safeguard analysis of the residue freed from alkalies was likewise made, and in the course of this 0·0019 gram of Cr_2O_3 was further obtained; the chromium being separated from the aluminium by chlorination of the solution of the mixed oxides in caustic soda, after expulsion of the iron by the Deville-Cooke method. The amount of chromite corresponding to the total 0·0028 gram of Cr_2O_3 is 0·0041 gram: and for 0·5115 gram of the material, 0·0042 gram.

After fusion with alkaline carbonates, 0·5115 gram of the material yielded only 0·0023 gram of undecomposed chromite (§64): the two results are compatible with the inferences already made (§63), namely, that part of the chromite (0·0019 gram) was decomposed during the fusion with the alkaline carbonates, and that the chromium of the decomposed portion, after precipitation with the iron and aluminium, was slowly expelled during the separation of the alumina from the ferric oxide: even when the silicates of a residue containing chromite are decomposed by hydrofluoric acid, the passage of chromium into solution has to be looked for.

73. (4.) 0·5000 gram of the residue left undissolved by the water, alcohol, and ether, gave:—mixed alkaline salts, before and after evaporation with sulphuric acid, 0·0172 gram and 0·0179 gram respectively, potassium chloride 0·0022 gram.

Part III.—Interpretation of the Analytical Results.

74. *Atomic Weights.* The atomic weights used in the following calculations are those adopted by Muir and Morley (1888) in their third edition of Watts' Dictionary of Chemistry, namely:—

Al	27·02	Cu	63·2	Na	23
Ba	136·8	Fe	55·9	Ni	58·6
Ca	39·9	H	1	O	15·96
Cl	35·37	K	39·04	P	30·96
Co	59	Mg	24	Pt	194·3
Cr	52·4	Mn	55	S	31·98.

It is convenient to make the calculations in the following order.

1. Residue undissolved by hydrochloric acid.

A. *After being boiled with sodium carbonate and caustic soda.*

75. *Alkalies.* After allowing for 0·0057 gram of mixed sulphates and 0·0007 gram of potassium chloride as deduced from the blank experiments (§69), it is seen that 0·5014 gram of residue (§72) yielded 0·0145 gram of mixed sulphates and 0·0012 gram of potassium chloride: these correspond to K_2SO_4 −0·0014 gram, Na_2SO_4 −0·0131 gram, and to K_2O −0·000757 gram, Na_2O −0·00572 gram. Hence for 0·5115 gram of residue, the numbers are K_2O −0·0008 gram, Na_2O −0·0058 gram. It must be remembered that the residue has been boiled with strong soda solution (§50), and that the completeness of the removal of adherent soda is necessarily uncertain.

76. (Fe_2O_3, Cr_2O_3) −0·0943 gram (§64). Since 0·0019 gram of chromite has passed into solution (§72), the corresponding 0·0013 gram of Cr_2O_3 will be contained in the 0·0943 gram of mixed oxides, and the Fe_2O_3 itself will be 0·0930 gram: further, 0·0007 gram of this corresponds to the iron of the decomposed chromite: hence the Fe_2O_3 corresponding to the silicate is 0·0923 gram, and is equivalent to FeO −0·0831 gram. The higher proportion of chromite agrees very satisfactorily with the direct determination of the amount of chromite left undecomposed by hydrofluoric and sulphuric acids (§§39, 109).

$Mg_2P_2O_7$ −0·3241 gram (§64) corresponds to MgO −0·1169 gram.

MnS −0·0025 ,, (§64) ,, ,, MnO −0·0020 ,,

77. Hence (§64) we deduce for the residue undissolved by hydrochloric acid:—

Chromite	...	...	0·0042 gram	
SiO_2	...	...	0·2769 ,,	silicate 0·5073 gram
Al_2O_3	...	...	0·0011 ,,	
FeO	...	...	0·0831 ,,	
MnO	...	...	0·0020 ,,	
MgO	..	...	0·1173 ,,	
CaO	...	...	0·0203 ,,	
Na_2O	...	...	0·0058 ,,	
K_2O	...	...	0·0008 ,,	
		Total	0·5115 gram	
		Taken	0·5115 ,,	

78. The silicate has thus the following percentage composition :—

		Oxygen.	
SiO_2	54·58	28·93	
Al_2O_3	0·22	0·10	
FeO	16·38	3·64	
MnO	0·40	0·09	14·58
MgO	23·12	9·24	
CaO	4·00	1·14	
Na_2O	1·14	0·29	
K_2O	0·16	0·03	
	100·00		

79. This is the composition after the material has been boiled with the soda mixture; it corresponds very closely to a silicate having the enstatitic formula $R''O.SiO_2$: it is clear that three extractions with hydrochloric acid (§48) are at least sufficient for the complete removal of the olivinic silicate.

80. *Weight of total residue undissolved by the hydrochloric acid.*

(α). Weight of residue in dish 1·0292 gram (§ 51).

(β). Weights of ignited residues 0·0121 gram and 0·0817 gram respectively (§§ 52, 50), or together 0·0938 gram: according to the last paragraph these correspond to 0·0921 gram of unignited residue.

The total residue before ignition would thus be 1·1213 gram, consisting of 0·0092 gram of chromite and 1·1121 gram of silicate having the percentage composition given in § 78.

B. *Before being boiled with sodium carbonate and caustic soda.*

81. To find the composition of the undissolved silicate before the action of the solution by means of which the liberated silica was extracted, it is necessary to take account of the bases found in the sodium carbonate and caustic soda solution (§ 53): the amounts found correspond to the action of that solution upon an amount which yielded 1·1121 gram of undissolved silicate (§80), if we assume that the bases are due to such action, and not to the adherence to the undissolved silicate of the solution containing the bases of the silicate dissolved by the acid.

The bases corresponding to $Mg_2P_2O_7$ —0·0031 gram, Fe_2O_3 —0·0088 gram are MgO —0·0012 gram, FeO —0·0079 gram: the weight of CaO was determined to be 0·0029 gram.

82. If these correspond to silicates of the above type $R''O.SiO_2$ we have:—

	MgO	FeO	CaO	Total
	0·0012 gram	0·0079 gram	0·0029 gram	0·0120 gram
SiO_2	0·0018 ,,	0·0066 ,,	0·0031 ,,	0·0115 ,,
			Silicate	0·0235 ,,

The above silica 0·0115 gram, due to the action of the sodium carbonate and caustic soda on the enstatitic residue, will have passed into the main silica resulting from the decomposition of the other silicate by the hydrochloric acid and must be deducted therefrom.

83. As only 0·5073 gram of the undissolved silicate (§77), not the whole 1·1121 gram (§80), was used for analysis, the corresponding bases and silica to be added will be:—

MgO	...	...	0·0006 gram
FeO	...	...	0·0036 ,,
CaO	...	...	0·0013 ,,
SiO_2	...	...	0·0052 ,,

84. Hence the composition of the undecomposed silicate, before the action of the sodium carbonate and caustic soda solution, will be given by the following (§§66, 77, 83).

			Total	Percentages	Oxygen	
SiO_2	0·2769	+0·0052	0·2821	54·46	28·87	
MgO	0·1173	+0·0006	0·1179	22·76	9·09	
FeO	0·0831	+0·0036	0·0867	16·74	3·72	
CaO	0·0203	+0·0013	0·0216	4·17	1·19	
MnO	0·0020		0·0020	0·39	0 09	14·51
Al_2O_3	0·0011		0·0011	0·21	0·10	
K_2O	0 0008		0·0008	0·15	0·03	
Na_2O	0·0058		0·0058	1·12	0·29	
Li_2O	trace		trace	trace		
	0·5073	0·0107	0·5180	100·00		

85. C. For *the total undissolved by the hydrochloric acid*, we have (§§80, 82):—

Chromite	... ...	0·0092 gram
Silicate undissolved by HCl	undissolved by Na_2CO_3, NaHO	1·1121 gram
	dissolved ,, ,, ,,	0·0235 gram
	Total	1·1448 gram

2. Unattracted material: mercurialised residue.

A. *Alkalies.*

86. (*a.*) After allowing for 0·0057 gram of mixed sulphates and 0·0007 gram of potassium chloride, as deduced from the blank experiments, it is seen that 0·5001 gram (§71) of the mercurialised residue (before being acted upon with hydrochloric acid) yielded 0·0066 gram of mixed sulphates and 0·0007 gram of potassium chloride: corresponding to K_2SO_4 −0·0008 gram, Na_2SO_4 −0·0058 gram, and to K_2O −0·0004 gram, Na_2O −0·0025 gram: hence 2·5748 grams of this residue contain K_2O −0·0021 gram, Na_2O −0·0128 gram.

(*b.*) 2·5748 grams of this residue (§48) are found to yield 1·1213 gram (§80) undissolved by HCl: further, the 1·1213 grams contain K_2O 0·0018 gram and Na_2O −0·0127 gram (§78). Hence, practically, the whole of the alkalies in the mercurialised residue belong to the part which is not dissolved by the hydrochloric acid: the alkalies found in the HCl solution (§§ 59, 60) after the removal of the other bases are thus derived from the action on the vessels, and must be neglected (§122).

B. *Mercurialised residue: troilite and schreibersite.*

87. The 0·0013 gram of $BaSO_4$ obtained from 0·7671 gram of mercurialised residue (§46) correspond to S 0·000178; hence 2·5748 grams of the residue will contain S −0·0006 gram, which, if still present as FeS, is combined with 0·0012 gram of Fe (corresponding to 0·0015 gram of FeO) to form 0·0018 gram of FeS (troilite): 1 gram of the residue contains S−0·00023 gram, corresponding to Fe−0·00041 gram; the latter corresponds to Fe_2O_3 −0·00059 gram.

The schreibersite present is only a trace.

Hence almost the whole of the troilite and schreibersite was removed during the repeated reduction in hydrogen and the treatment with mercuric solution (§42).

88. C. 2·5748 grams of the mercurialised residue (§48) were acted upon with hydrochloric acid, and the liberated silica was extracted from the residue by means of sodium carbonate and caustic soda; since 0·0052 gram of MnS corresponds to 0·0042 gram of MnO, and 0·3540 gram of Fe_2O_3 to 0·3186 gram of FeO, we have the following (neglecting the alkalies as explained above):

SiO_2	0·5932 gram	(§52)	
MgO	0·5089 ,,		
FeO	0·3186 ,,		
CaO	0·0078 ,,	(§58)	
MnO	0·0042 ,,		
Al_2O_3	0·0024 ,,		
NiO (CoO)	0·0005 ,,		
S	0·0006 ,,	(§87)	

89. D. As already shown (§82), 0·0115 gram of the silica belong to the enstatite brought into solution by the sodium carbonate and caustic soda: further, from the 0·3186 gram of FeO must be deducted 0·0015 gram of FeO, which contains the 0·0012 gram of Fe required to combine with 0·0006 gram of S to form troilite (§87); also the nickel (cobalt) oxide is not present as such, but either as metallic nickel (cobalt) (0·0004 gram of metal), which has escaped the mercuric solution, or as schreibersite, more probably the former.

Hence, for the silicate decomposed by the HCl, we have:—

			Percentages.	Oxygen.	
SiO_2	...	0·5817	40·90	21·68	
MgO	...	0·5089	35·78	14·29	
FeO	...	0·3171	22·30	4·95	
CaO	...	0·0078	0·55	0·16	19·55
MnO	...	0·0042	0·30	0·07	
Al_2O_3	...	0·0024	0·17	0·08	
		1·4221	100·00		

90. This corresponds very approximately to a silicate of the olivinic type $(R''O)_2SiO_2$.

It must be remembered that the silicate has been repeatedly heated to low redness in hydrogen and afterwards treated with mercuric solution, and may thus have undergone some alteration (§42): further, that the hydrochloric extract will contain besides the olivinic silicate the "glass and substance resembling glass" mentioned by Professor Ulrich, and some dissolved enstatite.

91. E. The following is the result of the analysis of 2·5748 grams of the mercurialised residue:—

Dissolved by HCl.....	Silicate	1·4221	(§89)
	Troilite	0·0018	(§87)
	Nickel (Cobalt)	0·0004	(§89)
Not dissolved by HCl	Chromite	0·0092	(§85)
	Insoluble in Na_2CO_3, NaHO...	1·1121	
	Soluble „ „ „ ...	0·0235	
	Total	2·5691	
	Taken	2·5748	(§48)

3. Unattracted material: before action of mercuric solution.

92. *Troilite.* 1·0693 gram of the unattracted material (§36) gave

·1730 gram of $BaSO_4$, corresponding to 2·2293 per cent. of sulphur, combined with 3·8986 per cent. of iron to form 6·1261 per cent. of troilite; hence, 5·6880 grams will contain 0·34845 gram of troilite, consisting of S—0·12680 gram and Fe—0·22165 gram (corresponding to Fe_2O_3—0·3166 gram).

93. *Schreibersite.* 1·0693 gram of the unattracted material (§37) gave 0·0038 gram of $Mg_2P_2O_7$: taking the schreibersite to have the composition Fe_2NiP_2, this corresponds to 0·09951 per cent. of phosphorus combined with 0·35934 per cent. of iron and 0·18835 per cent. of nickel, forming 0·6472 per cent. of schreibersite: 0·35934 gram of Fe corresponds to Fe_2O_3—0·51324 gram. Hence, 5·6880 grams of unattracted material will contain 0·0368 gram of schreibersite consisting of P—0·0057 gram, Fe—0·0204 gram (corresponding to Fe_2O_3—0·0292 gram), and Ni—0·0107 gram.

4. Unattracted material: portion dissolved by the mercuric solution, before and after reduction in hydrogen.

94. 5·6880 grams were acted upon in this series of operations (§40): the solution contains not only the unattracted metal and the metallic part due to the reduction of the rust (of which the state of oxidation is undetermined), but also the greater part of the troilite and schreibersite, for these minerals disappear almost wholly as such during the operations: further, there has been appreciable action on one or more of the silicates, probably almost wholly on the olivine, which is most easily altered.

95. *State of oxidation of the rust.*—Since only 0·0007 gram of Fe_2O_3 was obtained from 5·6880 grams of the material by means of mercuric solution before the reduction (§40), and 0·5138 gram of Fe_2O_3 was obtained from the same material by means of mercuric solution after the reduction (§44), it is clear that much of the iron was present in the state of rust. The composition of iron-rust is generally said to be (Fe_2O_3, xH_2O), but this will only be true in the extreme case. It had been found that there was considerable rust also in the attracted portion, as will be discussed later; the colour of this is dark grey, and not suggestive of the higher state of oxidation, while it is strongly attracted by the magnetic needle. Its characters, and, as will be later shown (§113), the numerical results, suggest that the iron-rust of the attracted portion is wholly, or almost so, of the composition Fe_3O_4: further, Professor A. Liversidge,[1] after examination of a large number of specimens of the rust

[1] *Trans. Australasian Assoc. f. Adv. of Sc.*, 1892.

of artificial iron, recently found that Fe_3O_4 is almost always present, and sometimes even forms the whole. As for the nickel, it is probably not oxidised at all, and before reduction of the rust by hydrogen was largely sheltered from the mercuric solution by the enclosing iron rust.

96. During the analysis of the attracted material it was for some time thought that there was possibly an action of the mercuric solution on the rust itself; but later the slightness of the action of the mercuric solution on the unattracted material before reduction, which still contains a large proportion of admixed rust, showed that this was not the case as regards the oxide of iron, and further that the alloy itself had been completely removed by the magnet: the existence of metallic nickel in the material at that stage of the analysis is accounted for by the fact that when separated from the metallic iron by the rusting of the latter, its feebler magnetic properties would allow of its being left behind with the rust. It had been hoped that in the part of the meteoric stone which had been selected for analysis as being least altered, even the iron had escaped oxidation: doubtless on the more weathered side of the stone, where there is an evident difference of colour, the iron has been converted into the higher oxide and hydrated.

97. As some of the troilite is still left in the mercurialised residue, it becomes necessary to know the total amount of mercurialised residue before we can say how much of the iron dissolved in the mercuric solution is due to the troilite. As already indicated, this could not be directly determined, but it may be calculated as follows:—

Let x grams be the total amount of the residue: they will contain $0{\cdot}00023x$ gram of S corresponding to $0{\cdot}00041x$ gram of Fe, $0{\cdot}00059x$ gram of Fe_2O_3, and $0{\cdot}00064x$ gram of troilite (§87). The 5·6880 grams of material contain 0·34845 gram of troilite (§92): hence the total amount of troilite dissolved is $0{\cdot}3484 - 0{\cdot}00064x$ gram, corresponding to $(0{\cdot}3166 - 0{\cdot}00059x$ gram) of Fe_2O_3 (§§ 87, 92).

98. The weights deduced for the ante-reduction extracts were (§40):—

Fe_2O_3 — 0·0007 gram: this we may assume to have been present before mercurialisation as iron (0·0005 gram) in combination with nickel, and to have escaped attraction by the magnet through entanglement in the unattracted material.

NiO(CoO) — 0·0048 gram: probably present as nickel (cobalt) 0·0038 gram.

SiO_2	0·0003	,,	0·0059 gram: probably due to action on the olivine during the weathering, or during the treatment with mercuric solution itself: boiling water would extract 0·0306 gram of sulphate and chloride from this amount of material (§31).
MgO	0·0017	,,	
CaO	0·0039	,,	

99. The weights deduced for the post-reduction extracts were (§44):—

Fe_2O_3 0·5138 gram: probably present as Fe_3O_4 (rust), troilite, and schreibersite; the presence of some Fe_2O_3 in the unattracted material, however, is suggested by the reddish brown colour (§17).

NiO (CoO) 0·0382 gram: probably present as nickel (cobalt) (0·0300 gram), partly set free by the rusting of the iron of the nickel-iron, and partly in combination as schreibersite.

SiO_2 0·0054 gram
CaO 0·0135 ,,
MgO 0·0049 ,,

} 0·0238 gram: in great part probably due to action on the olivine, though part of the CaO is due to action on the vessels during the separation of the nickel.

100. Since the whole of the schreibersite (0·0368 gram) has gone into solution (§§ 46, 93) it will yield 0·0292 gram of Fe_2O_3 and 0·0107 gram of Ni.

Hence of the 0·5138 gram of Fe_2O_3, 0·0292 gram will be due to schreibersite and the remainder, 0·4846 gram, to troilite and rust: from this above $(0{\cdot}3166-0{\cdot}00059\ x)$ gram is due to troilite: hence the residue $(0{\cdot}1680+0{\cdot}00059\ x)$ gram will be due to rust, and this amount corresponds to $(0{\cdot}1624+0{\cdot}00057\ x)$ gram of Fe_3O_4.

Of the total ante-reduction and post-reduction nickel (cobalt) 0·0338 gram, 0·0107 gram is seen to be due to the 0·0368 gram of schreibersite; hence the amount present as metallic nickel (cobalt) will have been 0·0231 gram.

101. Hence we see that the 5·6880 grams subjected to the action of the mercuric solution must have consisted of:—

Olivinic bases and silica which pass into solution	... ...	0·0297 gram
Metallic iron	...	0·0005 ,,
Metallic nickel (cobalt) ...	...	0·0231 ,,
Magnetic oxide of iron ...	...	$0{\cdot}1624+0{\cdot}00057x$ gram
Schreibersite	...	0·0368 gram
Troilite which passes into solution	...	$0{\cdot}3484-0{\cdot}00064x$ gram
Mercurialised residue (including some troilite which does not pass into solution)	... ...	x grams
Total		$0{\cdot}6009+0{\cdot}99993x$ gram;

whence $x=\frac{5{\cdot}0871}{0{\cdot}99993}=5{\cdot}0875$ grams.

The whole of the residue, if it could have been collected, would have thus amounted to 5·0875 grams.

102. Hence the 5·6880 grams of unattracted material will consist of the following:—

Olivinic bases and silica which pass into solution	0·0297 gram	0·0767 gram
Metallic iron	0 0005 ,,	0·0013 ,,
Metallic nickel (cobalt) ...	0·0231 ,,	0·0597 ,,
Magnetic oxide of iron ...	0·1653 ,,	0·4270 ,,
Schreibersite	0·0368 ,,	0·0951 ,,
Troilite which passes into solution ...	0·3451 ,,	0·8914 ,,
Mercurialised residue (including some troilite which did not pass into solution) ...	5·0875 grams	13·1417 grams
Total	5·6880 ,,	14·6929 ,,

The numbers in the second column are those which correspond to the whole of the unattracted material.

103. To find the composition of the olivine before the action of the mercuric solution and the repeated reduction in hydrogen, we must allow for the olivinic bases and silica which have entered into the mercuric solution: the weights actually obtained (§§98-99), namely,

SiO_2	0·0057 gram
CaO	0·0174 ,,
MgO	0·0066 ,,
	0·0297 ,,

were brought into solution in an experiment in which 5·0875 grams was the weight of the residue, as calculated above. Hence, for the portion 2·5748 grams (§48) the corresponding amounts will be:—

SiO_2	0·0029 gram
CaO	0·0088 ,,
MgO	0·0033 ,,
	0·0150 ,,

104. Neglecting the indeterminate FeO brought into solution by the

rtial alteration of the olivine, we have for the original composition of e olivine before the mercuric action (§89)

			Total	Percentages	Oxygen	
SiO_2	0·5817 gram	+0·0029 gram	0·5846 gram	40·68	21·56	
MgO	0·5089 ,,	+0·0033 ,,	0·5122 ,,	35·64	14·24	
FeO	0·3171 ,,	,,	0·3171 ,,	22·06	4·90	
NiO	0·0078 ,,	+0·0088 ,,	0·0166 ,,	1·16	0·33	19·62
MnO	0·0042 ,,	,,	0·0042 ,,	0·29	0·07	
Fe_2O_3	0·0024 ,,	,,	0·0024 ,,	0·17	0·08	
	1·4221 gram	+0·0150 gram	1·4371 gram	100·00		

105. Since 22·06 grams of FeO correspond to 24·51 grams of Fe_2O_3, 0 grams of olivine will increase to 102·45 grams on ignition in air.

106. The 2·5748 grams of mercurialised residue have thus been und to consist of (§91) :—

Metallic nickel (cobalt)	...	...	0·0004 gram
Residual troilite ...	...	...	0·0018 ,,
Chromite ...	...	...	0·0092 ,,
Enstatite ...	...	...	1·1356 ,,
Mercurialised olivine	...	...	1·4221 ,,
		Total	2·5691 grams
		Taken	2·5748 ,,

107. Hence for the total amount 13·1417 grams of mercurialised sidue corresponding to the whole of the unattracted material we should ve :—

Metallic nickel (cobalt)	...	...	0·0020 gram
Residual troilite ...	...	...	0·0092 ,,
Chromite ...	...	...	0·0471 ,,
Enstatite ...	...	...	5·8089 grams
Mercurialised olivine	...	...	7·2745 ,,
			13·1417 ,,

108. The 14·6929 grams of unattracted residue will therefore consist t the following (§102) :—

Metallic iron		0·0018 gram
Metallic nickel (cobalt)		0·0597 ,,
Magnetic oxide of iron		0·4270 ,,
Schreibersite		0·0951 ,,
Troilite (entering into solution)		0·8914 ,,
Olivinic bases and silica (ditto)		0·0767 ,,
Mercurialised residue 13·1417 grams	Metallic nickel	0·0020 ,,
	Troilite ...	0·0092 ,,
	Chromite ...	0·0471 ,,
	Enstatite ...	5·8089 grams
	Mercurialised olivine	7·2745 ,,
		14·6929 ,,

109. Or combining corresponding terms and including the trace o copper (§43):—

Metallic iron	0·0018 gram
Metallic nickel (cobalt)	0·0617 ,,
Copper	trace
Magnetic oxide of iron	0·4270 ,,
Troilite	0·9006 ,,
Schreibersite	0·0951 ,,
Chromite	0·0471 ,,
Olivine	7·3512 grams
Enstatite	5·8089 ,,
	14·6929 ,,

The above amount of chromite is 0·32 per cent. of the unattracte material: the actual percentage of chromite undissolved by the HF an H_2SO_4 was 0·34 per cent. or 0·29 per cent., according as we take th weight on the filter or the weight after ignition to be more correct (§39

Attracted material: weight 0·4791 gram.

110. Taking 0·2471 gram of the attracted material (§18) the follow ing numbers have been obtained:—

		Fe_2O_3	NiO(CoO)
1.	*Dissolved* (§§21, 22)		
A.	First seven extracts by mercuric solution	0·1666 gram	0·0308 gra
B.	Next five ,, ,, ,, ,,	0·0032 ,,	0·0024 ,,
		0·1698 ,,	0·0332 ,,

Compare these with the numbers obtained for the action of the mercuric solution on the unattracted material, namely :—

	Fe_2O_3	NiO(CoO)
C. Ante-reduction extracts (§40) ...	0·0007 gram	0·0048 gram
D. Post-reduction extracts (§44) ...	0·5138 ,,	0·0382 ,,

From a comparison of C and D, it is beyond doubt that much of the extracted iron was present in the unattracted material in the state of oxide, for the quantity of troilite in the unattracted material is not sufficient to account by its alteration for this large quantity (0·5138 gram) of Fe_2O_3: further, it follows from C that the mercuric solution had practically no solvent action on the oxide of iron itself. Hence it is inferred that in B the Fe_2O_3 is due to the presence of iron (alloyed with nickel) which has been sheltered from the mercuric solution by the oxide, but in that case it is likely that the NiO(CoO) obtained is throughout due to nickel (cobalt) in the metallic state (or in small part as schreibersite). Indeed, it is clear *a priori* that if the nickel itself is not oxidised during this initial stage of weathering, it will be finely distributed through the iron-rust and well sheltered from the action of the mercuric solution until the oxide of iron itself has been reduced and brought into solution.

111. With the above interpretation, the 0·1698 gram of Fe_2O_3 was present in the attracted material as 0·1189 gram of metallic iron, and the 0·0332 gram of NiO(CoO) as 0·0261 gram of metallic nickel (cobalt), forming 0·1450 gram of nickel-iron having the percentage composition iron 82, nickel (cobalt) 18.

112. *2. Boat Residue.*

This weighed 0·0705 gram, after being heated in hydrogen below 100° C. (§26).

The 0·0036 gram of SiO_2 (§28), if due to olivine, would originally be combined with 0·0032 gram of MgO, 0·0020 gram of FeO, and 0·0001 gram of CaO to form 0·0089 gram of olivine (§89).

The 0·0400 gram of Fe_2O_3 (§30) corresponds to 0·0360 gram of FeO : this 0·0020 gram is due to the 0·0089 gram of olivine : so that 0340 gram corresponds to rust, which will weigh 0·0365 gram if the oxide be Fe_3O_4.

(Ni, Co, Mg)O —0·0270 gram (§30) : of this 0·0032 gram is due to the 0089 gram of olivine, so that 0·0238 gram corresponds to metallic nickel (cobalt) 0·0187 gram.

The ignited enstatite weighs 0·0063 gram (§29), and corresponds to 0062 gram of unignited enstatite (§84).

113. If the iron-rust be assumed, as before, to be Fe_3O_4, we have :—

Fe_3O_4	...	...	0·0365 gram
Ni(Co)	...	...	0·0187 ,,
Olivine	...	...	0·0089 gram
Enstatite	...	...	0·0062 ,,
		Total	0·0703 ,,
		Actual weight	0·0705 ,,

The equality of the actual and calculated weights is sufficient to justif the above interpretation of the state of oxidation of the magneticall attracted rust.

114. *3. Ignited residue* (§24).

If the 0·0703 gram of residue in the boat were ignited, it would yield

Fe_2O_3	...	...	0·0378 gram
NiO(CoO)	...	...	0·0238 ,,
Ignited olivine		...	0·0091 ,,
Ignited enstatite		...	0·0063 ,,
		Total	0·0770 ,,

Hence, if the percentage composition before ignition of the 0·030 gram of ignited residue which had adhered to the filter corresponde exactly to that of the residue in the boat (which would only be tru approximately), the ignited residue would itself correspond to 0·028 gram of unignited residue.

115. We then have :—

Nickel-iron dissolved (§111)	...	0·1450 gram	
Boat residue (§113)	... ...	0·0703 ,,	} 0·0983 gra
Approximate weight of ignited residue before ignition (§114)		0·0280	
	Total	0·2433 ,,	
	Taken	0·2471 ,,	

116. 0·0983 gram of residue having the composition of that in t boat (§113) would consist of

Fe_3O_4	...	...	0·0510 gram
Ni(Co)	...	...	0·0262 ,,
Olivine	...	...	0·0124 ,,
Enstatite	...	...	0·0087 ,,
		Total	0·0983 ,,

117. The 0·2471 gram of attracted material will thus consist of

0·1450 gram (§111)	Fe	0·1189 gram	
	Ni(Co)	0·0261 ,,	
0·0983 gram (§116)	Ni(Co)	0·0262 ,,	
	Fe_3O_4	0·0510 ,,	
	Olivine	0·0124 ,,	
	Enstatite ...	0·0087 ,,	
	Total	0·2433 ,,	

118. Hence, now including the trace of copper (§19), the total attracted material, 0·4791 gram, will consist of (§117):—

Metallic iron	0·2342 gram
Metallic nickel (cobalt)	0·1030 ,,
Metallic copper	trace
Magnetic oxide of iron	0·1004 ,,
Olivine	0·0244 ,,
Enstatite	0·0171 ,,
Total	0·4791 ,,

119. For the whole material (attracted and unattracted) we thus have (§§109, 118):—

		Percentages
Metallic iron	0·2355 gram	1·55
Metallic nickel (cobalt)	0·1647 ,,	1·08
Copper	trace	trace
Magnetic oxide of iron	0·5274 ,,	3·48
Olivine	7·3756 grams	48·61
Enstatite	5·8260 ,,	38·40
Troilite	0·9006 gram	5·94
Schreibersite	0·0951 ,,	0·63
Chromite	0·0471 ,,	0·31
	15·1720 grams	100·00

The differences from the preliminary numbers mentioned in Professor Ulrich's paper are due to an assumption, found later to be incorrect (§46), that only a negligible amount of the iron in the mercuric extract of the reduced unattracted material was due to alteration of the troilite.

120. The 3·48 per cent. of Fe_3O_4 being due to the weathering of 2·52

of metallic iron, the percentage composition of the stone before weathering would be

Nickel-iron	...	...	5·20
Olivine ...	...	...	49·08
Enstatite	...	...	38·77
Troilite ...	...	...	6·00
Schreibersite	...	...	0·64
Chromite	...	...	0·31
			100·00

121. 100 parts of the silicate portion would consist of 55·87 parts of olivine and 44·13 parts of enstatite.

100 parts of the original nickel-iron would consist of 78·94 parts of iron and 21·06 parts of nickel (cobalt) (§119): the analysis of 0·1450 gram of the residual nickel-iron gave 82 of iron to 18 of nickel (cobalt) (§111).

The nickel and cobalt are in the proportion to each other of 4·7 : 1 (§44) or of 12 : 1 (§21): the former proportion was deduced from the analysis of reduced rust, the latter from analysis of the mercuric extract of the residual unrusted alloy itself, which may have a different composition.

122. *ALKALIES.*

(1). *Unattracted material.*

First determination. After deducting the 0·0062 gram of mixed chloride due to the blank 4·6803 grams of calcium carbonate (§69), the weight of the mixed chlorides due to 0·5851 gram of the unattracted material will be 0·0068 gram (§65). Further, 0·0028 gram of potassium platino-chloride and 0·0014 gram of platinum correspond respectively to 0·0009 gram and 0·0011 gram, and together to 0·0020 gram of KCl; deducting 0·0009 gram due to the blank calcium carbonate, the KCl due to the unattracted material is 0·0011 gram: whence the NaCl is 0·0057 gram and the KCl is 0·0011 gram. These correspond respectively to 0·12 per cent. of K_2O and 0·52 per cent. of Na_2O.

Second determination. After deducting 0·0057 gram of mixed sulphates due to 4 grams of blank calcium carbonate, the mixed sulphates due to the 0·4965 gram of the unattracted material (§70) will be 0·0082 gram; similarly, deducting 0·0007 gram of KCl due to the blank calcium carbonate, the KCl due to the unattracted material itself is 0·0009 gram. These correspond to K_2SO_4 0·0011 gram and Na_2SO_4 0·0071 gram: or to 0·12 per cent. of K_2O and 0·62 per cent. of Na_2O.

(2). *Mercurialised residue.*

It has been shown (§86) that in the mercurialised residue the percentages of K_2O and Na_2O are 0·08 and 0·50 respectively.

(3). *Hydrochloric acid extract.*

The weight of silicate decomposed by the acid was 1·4221 gram (§91).

(*a*). The KCl from the first filtrates (§59) was 0·0013 gram, corresponding to K_2SO_4 0·0015 gram: the mixed sulphates weighed 0·0159 gram: hence the Na_2SO_4 weighed 0·0144 gram: these correspond to 0·0008 gram of K_2O and 0·0063 gram of Na_2O, or to 0·06 per cent. of K_2O and 0·44 per cent. of Na_2O.

(*b*). The KCl from the later filtrates (§60) was 0·0009 gram, corresponding to 0·0011 gram of K_2SO_4: the mixed sulphates weighed 0·0047 gram: hence the Na_2SO_4 weighed 0·0036 gram: these correspond to 0·0006 gram of K_2O and 0·0016 gram of Na_2O, or to 0·04 per cent. of K_2O and 0·11 per cent. of Na_2O.

The latter amounts must be due to the action on the glass and porcelain vessels: if we assume that there was an equal amount of action in the earlier part of the analysis, the percentages due to action on the silicate itself will be 0·02 per cent. of K_2O and 0·32 per cent. of Na_2O.

It has been inferred elsewhere that there were practically no alkalies extracted by the acid (§86).

(4). *Insoluble residue*

It has been already shown (§84) that in the residual silicate undissolved by hydrochloric acid the percentages of K_2O and Na_2O are 0·15 and 1·12 respectively. As the silicate was freed from admixed silica by boiling with strong soda solution, it is not unlikely that traces of the latter may have adhered to the silicate even to the end of the boiling with distilled water.

(5). *Unattracted material (after treatment with water, alcohol and ether).*

After deducting 0·0057 gram of mixed sulphates due to 4 grams of blank calcium carbonate, the mixed sulphates due to 0·5 gram of this residue (§73) will be 0·0122 gram: similarly, deducting 0·0007 gram of KCl due to the blank calcium carbonate, the KCl due to the residue itself is 0·0015 gram. These correspond to K_2SO_4 0·0018 gram and Na_2SO_4 0·0104 gram; or to 0·10 per cent. of K_2O and 0·48 per cent. of Na_2O.

The above numbers are consistent in indicating that the alkali present is essentially soda, and is almost wholly if not solely present in a mineral

constituent which is only slightly attacked by water, alcohol, ether, or dilute hydrochloric acid.

Chemical relationship to other meteoric stones.

123. For the olivinic silicate the ratio of the oxygen in combination with the iron and manganese to that in combination with the magnesium and calcium is 1 : 2·9 (§104); in this respect the Makariwa stone resembles those of Gopalpur (1 : 2·75), Mezö-Madaras and Eichstädt (1 : 2·8), Montréjeau and Pultusk (1 : 2·9), Borkut and Chantonnay (1 : 3).[1]

For the enstatitic silicate the corresponding ratio is 1 : 2·7 (§84): this approximates to those of Eichstädt (1 : 2·2), Manegaum, Waconda, and Tjabé (1 : 2·3), Seres (1 : 2·4), Georgia and Montréjeau (1 : 2·5), Grosnaja (1 : 2·6), Utrecht (1 : 2·7), Ski (1 : 2·8), Borkut (1 : 3).

Of the above meteoric stones that which stands nearest in this respect for both silicates is Montréjeau: other stones approximating to Makariwa in both ratios are Borkut, Eichstädt, Tjabé, Utrecht and Linn County. In the proportion of the olivine to the enstatite there is also a close similarity: in Makariwa the proportion is 56 : 44 (§120), in Montréjeau it is 54 : 46.

The proportion of nickel (18·21 per cent.) in the alloy is higher than the average (§120), and approximates to that of Middlesbrough (23 per cent).

Concluding Remarks.

124. As a result of the observations made in the course of the analysis of the Makariwa stone, the following points may be emphasised :—

1. It is advisable to first effect, as far as practicable, a magnetic separation of the mineral constituents: otherwise, owing to the malleability of the nickel-iron, the powdered material may be neither sufficiently fine nor sufficiently homogeneous as a mixture. Further, without this separation, the appreciable proportion of the iron-rust may escape observation.

2. The solution of mercuric ammonium chloride, suggested by Dr Friedheim, is very satisfactory in being without appreciable action on any other constituent than the nickel-iron, if used as directed.

3. If the attracted material be treated with acid without previous

[1] *Die Chemische Natur der Meteoriten*, von C. F. Rammelsberg. Berlin, 1879.

extraction by means of mercuric solution, the composition deduced for the nickel-iron may be completely wrong owing to the solution of iron-rust.

4. After reduction of the rust in the unattracted material by heating to low redness in hydrogen, and after subsequent treatment with the mercuric solution, no troilite or schreibersite will be left in the residue if the operations are sufficiently prolonged. There is a small, but appreciable effect on the silicate portion during the operations.

5. The enstatite can be completely freed from olivine by three extractions with hydrochloric acid (S.G. 1·06) on the water-bath, probably by two.

6. The Deville-Cooke method is very advantageous for the separation of the small quantities of aluminium and chromium from the iron.

It may be added that the microscopical characters of minerals have now been so minutely investigated that, for mere determination of the mineralogical species of the constituents, the microscopic examination of a thin section of a meteorite by the petrologist is more complete and expeditious than a chemical analysis.

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Nantokite from New South Wales.

By A. Liversidge, M.A., F.R.S., Professor of Chemistry, University of Sydney, N.S.W.

[Read April 10th, 1894.]

SOME specimens of this rare mineral have recently been kindly forwarded to me by Mr. J. R. McKay, Manager of the Broken Hill South Silver Mining Company, New South Wales, together with a report upon them by Mr. J. O. Armstrong of the above mine, and Mr. A. D. Carmichael of the Broken Hill Proprietary Block 10 mine, as follows:—

"Mineral found at the Broken Hill South Mine, at the 300 feet level in the carbonate of lead stopes, below original water level.

"It was found in one boulder about 2-3 feet diameter; the boulder consists principally of carbonate of lead, native and oxide of copper, with films of oxy-chloride of copper.

"The crystals on examination were found to consist wholly of copper and chlorine, a quantitative analysis showing:—

Copper	...	...	64·28
Chlorine	...	...	35·82
			100·10

"This corresponds extremely closely to the calculated percentage composition of cuprous chloride, Cu_2Cl_2, which is:—

Copper	...	...	64·18
Chlorine	...	...	35·82
			100·00

"At the time of making this examination only small portions of the mineral were available.

"S. G. (approx.) 4·3; insoluble in water, soluble in ammonia, hydrochloric acid and solution of common salt; on heating with water in presence of air it is decomposed, lemon-yellow coloured hydrated sub-oxide of copper being precipitated, which on further heating is changed into red

anhydrous sub-oxide, part of the copper going into solution as cupric chloride.

"(Signed) J. O. Armstrong, South Mine.
A. D. Carmichael, B. H. P. Block 10 Mine."

The properties of the specimens forwarded to me correspond with those given by Messrs. Armstrong and Carmichael, hence any additional analysis seems unnecessary.

The specimens received consisted of the mineral in its matrix of cuprite, associated with native copper, cerussite and a little quartz; the nantokite was of a pea-green tint with a slightly effloresced surface, there were also some selected pieces separated from the matrix, from $\frac{1}{4}$-inch to $\frac{1}{3}$-inch through; at first these possessed but a pale shade of green from superficial oxidation, but they gradually became of a darker green, and in two or three days the surface effloresced or became powdery; when freshly fractured the mineral is colourless and transparent, and has a highly vitreous or even adamantine lustre. The fracture is small-conchoidal, and an occasional cleavage plane is presented.

Before the blowpipe it fuses and colours the flame a vivid blue, and on charcoal leaves a globule of copper.

I found the specific gravity of these pure fragments to be 4·1 at 27° C., and the hardness 2·5.

Although the fragments look like portions of crystals, I could not identify any faces with certainty.

The mineral corresponds in all respects to the description given by Dana (*System of Mineralogy*, 1892, p. 154) of the original specimens found at Nantoko, Chili.

OBITUARY.

Ernest Mallard.

[Died July 19th, 1894.]

IN the history of scientific Mineralogy the name of M. Mallard will undoubtedly occupy a place beside that of Haüy, to whom is universally conceded the honour of originating this branch of human knowledge. His death took place at Paris, while he was in the apparent enjoyment of full health and vigour, at the age of 61.

It may be asserted without exaggeration that M. Mallard created anew the science of crystallised bodies by bringing that science into close and intimate union with general physics. Only a few years ago mineralogy was regarded as a purely descriptive science, resembling zoology or botany, and crystallography was no more than a special chapter of abstract geometry. Yet a crystal is by no means simply a figure; it is a body possessing a certain structure to which the form is related.

What is this structure, and how is it to be referred to the laws of symmetry to which all crystallised substances are subject? This great problem had often been vaguely entertained, but its solution was presented by M. Mallard in a manner which leaves nothing to be desired.

In this subject he was the close follower of Bravais, whose beautiful theory he, to his great credit, adopted, developed and popularised. Bravais, however, viewed the problem as a geometrician, and saw only one side of the question. The conception of the lattice is based upon the homogeneity of the crystal. Now experience had long ago shown that crystals are far from being always homogeneous. To M. Mallard is due the honour of explaining this apparent contradiction by demonstrating theoretically and experimentally that crystals frequently consist of several lattices distributed in a certain regular manner about an axis which does not belong to any one of them. This luminous conception at once solved all difficulties of interpretation, for it reduced all the apparent exceptions to the operation of a universally accepted law, the general law of symmetry.

M. Mallard did more than this, and hereon rests his claim to imperishable fame. He deduced from the theory of lattices and of reticular assemblages all the physical phenomena observed in crystallised bodies,

including what were called the optical anomalies. Crystallography in the widest acceptation of the term, the study of crystallised bodies, had been nothing more than a purely empirical science. It became, owing to the labours of M. Mallard, a completely rational science to the same extent as any other branch of physics, for from that time it possessed a general principle, from which all the laws of the observed phenomena can be directly deduced.

The theories of M. Mallard have been, as is well known, energetically opposed, especially in Germany; but this is the fate of all theories which open up new horizons, and for that very reason come as a shock to received ideas and established customs. They are, however, destined to spread more widely until they achieve their final triumph in scientific thought, when the present generation, which has been educated in the school of purely geographical crystallography, shall have been replaced by a new one.

The crowning work of M. Mallard was his *Traité de Cristallographie*, which was intended to comprise three volumes. Two only of these have appeared, in 1879 and 1884 respectively. The first is devoted to the geometrical and the second to the physical characters of crystals. The last volume was to have dealt with crystalline assemblages, polymorphism and isomorphism:—the most complex problems in crystallography, and those in which his most original work was done.

It is much to be regretted in the cause of science that the last and long-expected volume has not been published, but the materials from which it was to be constructed are to be found dispersed through the numerous memoirs issued by M. Mallard since 1879. Some of these memoirs are real masterpieces, and have become classical, such as the papers on optical anomalies, on the quasi-cubic form of all crystallised bodies, on the transformations of polymorphous substances, and on isomorphous mixtures. All these works are distinguished by a remarkable conciseness of style and lucidity of expression. On every page are to be found new ideas, brilliant generalisations and an altogether exceptional accuracy of observation.

Endowed with a powerful intellect and the spirit of the acute observer, M. Mallard excelled in that difficult art by which a problem is confined within its true sphere, is referred to a general scientific principle, and is solved without the aid of any hypothesis.

When in addition to the above-mentioned works relating to the general problems of crystallography we add the many detailed researches which he published in the Bulletin of the French Mine-

logical Society, some relating to improved instruments of precision, and some to particular mineral species, such as boleite, lussatite, tridymite, and melanophlogite, we cannot but feel that since the time of Haüy no one has done so much to advance that section of physical science which is concerned with crystallised bodies.

G. Wyrouboff.

REVIEWS.

C. Friedel. *Cours de Minéralogie.* Paris, 1893.

This text-book, which is a *resumé* of the author's lectures at the École Normale and the Faculté des Sciences, contains the general introduction to the subject, and is written in the clear and lucid style which we have learnt to expect in a French text-book.

Nearly three-quarters of the volume are devoted to the external characters of minerals, and the laws of crystalline symmetry are developed according to the principles laid down by Haüy and Bravais.

Here, however, as in all *mineralogical* text-books, we find little attention paid to recent theory, and no attempt to indicate the possibility of the 32 crystalline types. In spite of the investigations of Curie (to mention only a French worker in this subject) and the books of Liebisch, the importance of this theorem from an educational point of view appears to have attracted little attention. Undoubtedly the art of writing a readable text-book consists largely in the judicious omission of what is unnecessary, but to leave out a statement of the 32 groups in a text-book mainly occupied with crystallography is as unjustifiable as the omission of the Periodic law in a text-book of chemistry.

A considerable amount of space is well devoted to methods of calculation, always a stumbling-block in the path of the mineralogica student, but several pages are wasted over the customary comparison of different notations.

The latter portion of the book contains a sketch of the optical and physical characters, a somewhat too brief exposition of the principles of mineral chemistry, and a chapter of considerable value and interest upon the synthesis of minerals. Here, as might be expected from Professor Friedel, a far more comprehensive and intelligible survey of this important subject is given than can be found in any similar book.

A second volume, to be prepared with the collaboration of the author's son, is promised, and is to contain descriptions of the principal mineral species.

F. Pisani. *Les Minéraux usuels et leur essai chimique sommaire.* Paris, 1893.

This little book is designed for the use of miners, chemists, jewellers,

&c., and does not profess to do more than give a short summary of the characters of some of the best known minerals, especially as regards solubility, fusibility, action with acids and behaviour before the blowpipe. It may possibly serve the purpose for which it is written, but at the present time, when there are several excellent French text-books, we doubt whether it will supply a real want, and little books written in this tabular form are not calculated, we fear, to encourage a study of the science among beginners.

C. J. Woodward. *A B C Five-figure Logarithms for General Use.*

This is a handy little book of tables, in which the proportional parts are given by what the author has introduced in a previous book as the A B C system. The present tables are an enlargement and improvement of those in the earlier work, in that it contains the logarithms of arc functions as well as of numbers. The book is also provided with a lateral index which is extremely convenient for practical use.

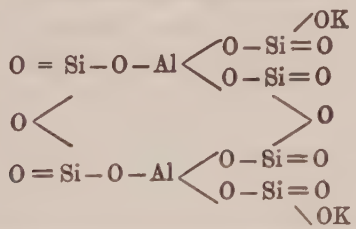
The tables are well adapted for the crystallographic calculations required by the mineralogical student, and we note with gratification that among the applications illustrated in an introductory chapter the author has included the formula for the positions of four poles in a crystal zone —certainly the first time that this formula has found a place in logarithmic tables for general use.

Abstracts.

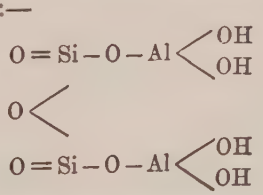
Structural formulæ of metasomatic alteration products. (R. Scharizer, *Zeitschrift für Krystallographie, XXII.* 1893, p. 369.) By metasomatic alteration products the author understands those substances which, when a mineral is decomposed, remain owing to their low degree of solubility, and take the external form of the primary mineral.

To explain these changes structural formulæ are used, with the atoms so linked, that on the separation of a definite group, so many valencies become free as will be satisfied by the incoming water or hydroxyl groups.

The kaolin series. Orthoclase is thus expressed :—



In conversion into kaolin the two univalent groups $RSiO_3$ and the divalent group Si_2O_5 are carried away, hydroxyl enters, and we get Groth's structural formula for kaolin :—



This also explains why the two molecules of water are equally held. The two formulæ are of the same type, and represent salts of dimetasilicic acid ($H_2Si_2O_5$), which are both insoluble in acids.

By the successive entrance of two hydroxyl groups we get :

Orthoclase $(K_2Al_2Si_6O_{16}) - 2(KSiO_3) + 2(HO) = (H_2Al_2Si_4O_{12})$ Pyrophyllite,
Pyrophyllite $(H_2Al_2Si_4O_{12}) - (Si_2O_5) + 2(HO) = (H_4Al_2Si_2O_9)$ Kaolin,
Kaolin $(H_2Al_2Si_2O_9) - (Si_2O_5) + 2(HO) = (H_6Al_2O_6)$ Hydrargillite.

These minerals also show certain crystallographic relations : kaolin and hydrargillite have good basal cleavage, and a percussion figure with the principal ray parallel to the plane of symmetry. In orthoclase, by making

u ($\bar{2}21$) the prism, and y ($\bar{2}01$) the orthopinacoid, c (001) remaining as th basal plane, we get the parameters given below; also, as before, there a basal cleavage on which a sort of percussion figure, with one ray parall to the plane of symmetry, may be obtained. The altered parameters an the angles show some agreement.

		β	(110):(1$\bar{1}$0)	(110):(00
Orthoclase:	$a : b : c = 0{\cdot}6586 : 1 : 1{\cdot}0123$;	80°22′;	66°	81°5
Kaolin:	$a : b : \frac{2}{3}c = 0{\cdot}5748 : 1 : 1{\cdot}0664$;	83°11′;	59°26′	84°5
Hydrargillite:	$\frac{1}{2}a : b : \frac{1}{2}c = 0{\cdot}5696 : 1 : 0{\cdot}9592$;	85°29′;	58°23′	86°7

Taking the deutero-pyramid of corundum as the primary pyramid an a clinodome we get:

$$a : b : c = 0{\cdot}5774 : 1 : 0{\cdot}9089;\ \beta = 90°$$

These figures are near to those in the above table.

Corundum, hydrargillite, kaolin and orthoclase are either rhomb hedral, or in the arrangement of their faces approach to rhombohedr forms; this is further brought out in the structural formulæ. In each these Al_2 forms the kernel, from which are three pairs of links. corundum each pair takes up an oxygen atom, and in hydrargillite (OH) in these two cases the structural formulæ are symmetrical about thr lines, while those of orthoclase, pyrophyllite, and kaolin only about on line. As hydrargillite is monoclinic and not rhombohedral, as would expected (the very small optic angle, however, shows an approach to this the author concludes that two of the double valencies of the Al_2 kern are not of equal value, and that kaolin (which contains two $(OH)_2$ grou and one Si_2O_5 group) may be anorthic, as has been supposed by Reusc

Tschermak's observation of the monosymmetric habit and the biaxi nature of corundum is considered to support the view that two of t links are of unequal value.

The Talc-Serpentine Series. This series is in many ways analogous to t kaolin series; talc ($H_2Mg_3Si_4O_{12}$) corresponds to pyrophyllite ($H_4Al_2Si_4O_1$ serpentine ($H_4Mg_3Si_2O_9$) to kaolin ($H_4Al_2Si_2O_9$), brucite ($H_6Mg_2O_6$) hydrargillite ($H_6Al_2O_6$). Calculating brucite as monosymmetric, t constants approach those of the kaolin series:

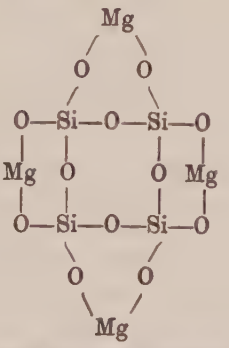
$$\frac{1}{3}a : b : \frac{2}{3}c = 0{\cdot}5773 : 1 : 1{\cdot}0131;\ \beta = 90°$$

Brucite and talc have basal cleavage and percussion figures; a furth analogy is brought out when the (010) cleavage of serpentine (to which optical bisectrix is nearly perpendicular) is taken as (001).

The chemical behaviour of the two series is different; the members the kaolin series are insoluble in acids, while brucite and serpentine a

easily attacked; and further, talc and serpentine are as a rule derived from different minerals.

Enstatite is written as follows:



As one atom of Mg passes out two hydroxyl groups become linked to two silicon atoms, and talc is the result; the type is unaltered, both minerals are metasilicates and are not attacked by acids.

Structural formulæ illustrating the change of olivine into serpentine are given; here the olivine is considered to be a salt of di-orthosilicic acid ($H_6Si_2O_7$), so that the resulting serpentine shall be of the same type, in accordance with the formula of Tschermak.

Non-aluminous amphibole or pyroxene is represented by the same formula as enstatite (given above), here when $MgSi_2O_3$ is removed and four hydroxyl groups enter, the result is serpentine; in this case the two formulæ are not of the same type, which is also indicated by the fact that one is attacked by acids and the other not. L. J. S.

Constitution of the Lithia Micas. (F. W. Clarke, *Journ. American Chem. Soc.* xv. 1893, p. 1.) The micas have been considered by Clarke as derivatives of normal aluminum orthosilicate.

Normal Salt	...	$Al_4(SiO_4)_3$.
Muscovite	...	$Al_3(SiO_4)_3R'_3$
Biotite ...	...	$Al_2(SiO_4)_3R''_2R'_2$.
Phlogopite	...	$Al(SiO_4)_3R''_3R'_3$
Clintonite	...	$R'\begin{matrix}O\\O\end{matrix}>Al-SiO_4 \equiv R'_3$

The lithia micas are characterised by an oxygen ratio lower than that of the orthosilicate, and by the presence of fluorine. The first is explained by the group Si_3O_8 replacing SiO_4; and in the second it was previously considered by the author that the fluorine was present in the univalent

group AlF_3 among the components of R′. This is now explained by assuming that the clintonite type may be replaced by the molecule

$$\left.\begin{matrix}F\\F\end{matrix}\right\rangle Al-SiO_4 \equiv R'_3.$$

In polylithionite SiO_4 is entirely replaced by Si_3O_8, and we have the molecules AlF_3,Si_3O_8,Li_3 and $Al(Si_3O_8)_3(Na_2K)_3$ in the ratio of 5 : 1; the composition calculated from this formula agreeing very closely with that found by analysis.

All variations in the composition of the lepidolites proper may be explained by the supposition that these micas are mixtures of the two typical molecules $AlF_2.Si_3O_8.R'_3$, where R′ is principally lithium, and a muscovitic molecule $Al_3(SiO_4)_3R'_3$ in which R'_3 may be K_2H or KH_2. Some peculiarities are explained by small mixtures of the molecule $AlF_2Si_2O_8.Al$.

Cookeite, which appears to be the vermiculite of the lepidolite series, has the fluorine replaced by hydroxyl, and we have a mixture of the three molecules $Al(OH)_2.SiO_4.Li_3$, $Al(OH)_3.SiO_4.H_3$ and $Al(OH)_3.SiO_4.Al$.

In the iron-lithia micas, zinnwaldite and cryophyllite, the case is more complicated, as the iron may belong to the molecule $AlF_2.Si_3O_8.Fe''R'$, or to the biotitic molecule $Al_2(SiO_4)_3Fe''_2R'_2$. Some zinnwaldites are represented by mixtures of AlF_2 $Si_3O_8.FeLi$, and $Al_3(SiO_4)_3K_3$, and cryophyllite is most easily represented by

$$Al_3X_3KH_2 + 2(Al_3X_3Fe_3H_2) + 8(AlF_3.X.K_3) + 4(AlF_3.X.Li_3);$$

in which X represents SiO_4 and Si_3O_8 in the ratio 1 : 3. L. J. S.

Canfieldite and Argyrodite.—Penfield (*Am. J. Sc. XLVI.* 1893, p. 107) describes a mineral from Bolivia occurring massive and in isometric crystals. The usual form is the octahedron, the edges of which are sometimes truncated by the dodecahedron. The faces not being very good, the readings for the octahedral angle vary from 70° 0′ to 70° 29′. Twinning sometimes occurs about an octahedral plane. Analysis gives:

S	...	...	17·03
Ge	...	...	6·51
Ag	...	...	76·01

Supposing the small quantities of Fe, Zn and insoluble matter to occur in the associated blende and pyrites, the recalculated analysis agrees still more closely with the formula $4Ag_2S.GeS_2$. Sp. gr. 6·26.

From his analysis of argyrodite Winkler deduced the formula $8Ag_2S.GeS_2$, while Penfield points out that $4Ag_2S.GeS_2$ agrees better with the analysis. He therefore makes a new analysis of the Freiberg argy

rodite, using the same methods as with the Bolivian mineral, and after deducting impurities as before, and calculating the mercury (0·34 %) as replacing silver, he arrives at the formula $4Ag_2S.GeS_2$. The sp. gr. was determined for the Freiberg mineral to be 6·15—6·16.

Argyrodite was described as monoclinic, and has a slightly lower sp. gr. than the cubic Bolivian mineral; Penfield therefore gives the name of Canfieldite to the latter mineral, and considers the two to be dimorphous.

Weisbach, before seeing Penfield's paper, had found (*Neues Jahrbuch für Min.*, &c. 1894, p. 98) that Argyrodite is really cubic; and that owing to the striation and curvature of the faces he was mistaken in determining the mineral as monoclinic. The faces previously recorded he now gives as the dodecahedron (*m* and *o*), tetrahedron (*k* and *f*), and $-\kappa\{311\}$ (*v*). He gives the twin axis as $\perp$ (111), and the composition face one of the (110) faces parallel to the twin axis.

Canfieldite is therefore identical with Argyrodite; it is unfortunate that Weisbach's correction was only published after the appearance of Penfield's paper.

In Penfield's paper is a full account of the blowpipe reactions of the mineral and of the methods of analysis. L. J. S.

Rare Argentine Minerals (F. Klockmann, *Zeitsch. f. Kryst.* XIX. 1891, p. 265).—*Eucairite.* The specimens are from the silver mines in Sierra de Umango, in the Province of La Rioja; they are granular in structure, the grains appearing to show cleavage, or at least a tendency to lamination. The composition is AgCuSe or Ag_2S+Cu_2Se. The author is more inclined to place the mineral in the galena than in the redruthite group. Intergrown with the eucairite is a mineral that has the outward appearance and chemical composition (HgSe) of tiemannite. The mineral occurs in limestone, and is associated with bornite, calcite, umangite and green alteration products of copper ores.

Umangite. This new mineral occurs with eucairite at the above locality and under the same conditions. It is only found in the massive state, and the specimens are covered with a thin crust of malachite and chalcomenite. No cleavage; fracture uneven to small-conchoidal; metallic lustre; colour on a fresh fracture dark cherry-red with a tinge of violet, soon tarnishing, the colour becoming violet-blue; streak black; analysis gives Cu_3S_2 ($=Cu_2S+CuS$). The mineral is very like bornite in appearance. It encloses eucairite.

Luzonite. The specimens described are from the mines of Cerro de la Mejicana, Sierra de Famatina, La Rioja. The mineral is only found

massive, and has a peculiar reddish-gray to light copper-red colour; on a fresh fracture it is reddish, and the metallic lustre is stronger. No cleavage; fracture small-conchoidal to uneven; streak black. H=3½; sp. gr.=4·39; analysis gave $8{\cdot}82Cu_3AsS_4+1Cu_3SbS_4$, that is 8·82 molecules of enargite to one of famatinite.

As luzonite and famatinite occur together at this locality, and are very like each other in appearance (both being only known massive), the author concludes that they are isomorphous, and gives the following isodimorphous group, in which one member is unknown:

Cu_3AsS_4	Enargite, rhombic	...	Luzonite, system?
Cu_3SbS_4	Unknown	...	Famatinite, system?

L. J. S.

Rowlandite. (W. E. Hidden and W. F. Hillebrand, *Am. J. Sc.*, *XLVI.*, Sept. 1893, p. 208).—This new mineral occurs with gadolinite and yttrialite in Llano County, Texas. The colour varies from bottle- to pale drab-green; the lustre is vitreous to resinous, and thin splinters are perfectly transparent; fracture conchoidal; powder light greenish grey. The mineral is isotropic; H=6; sp. gr.=4·515. It is easily soluble in acids. Before the blowpipe it intumesces, and becomes strongly incandescent without fusing. The glassy isotropic interior is surrounded by a reddish alteration substance, consisting chiefly of carbonates of the rare earths and lime.

The pure material gave, as important constituents:—

SiO_2 ...	...	...	26·04
Ce_2O_3	...	. .	5·06
La group	...	...	9·34
Y group	...	...	47·70
FeO ...	...	...	4·39
MnO ...	...	...	0·67
MgO ...	...	...	1·62
F ...	...	...	3·87

together with ThO_2, Fe_2O_3, CaO, H_2O, CO_2, P_2O_5, alkalies, uranium and titanium. The absorption spectrum of a saturated nitrate solution of the mineral showed the lines of the erbium and didymium groups very prominently.

From the analysis is deduced the formula $Si_4R_4'''R''F_2O_{14}$. A structural formula is given in which the mineral is regarded as a derivative of the acid $H_6Si_2O_7$.

L. J. S.

Occurrence and distribution of Nickel in the Rhenish district (H. Laspeyres, *Verhand. des naturh. Vereins*, 1893, pp. 143-273).—The nickel ores and the minerals and rocks containing nickel are described with special reference to this area, with mention of all the reported occurrences. The following are a few points of general interest :—

Beyrichite. Only one specimen is known, this is from the Lammerichskaule mine, near Altenkirchen. A fresh splinter in the air soon changes on the surface to millerite, as is seen by the change of colour from lead gray to brass yellow, this takes place first on the prism faces, then on the cleavages, and lastly on the fractured surfaces ; the whole surface having become yellow at the end of a week. Analyses of the separated mineral gave (Ni, Co, Fe)S, there being 2·02 % Co and 0·85 % Fe. (Liebe gave $(Ni, Fe)_5S_7$, but very probably he analysed polydymite and not beyrichite). Sp. gr. = 4·699. The great differences in the density (4·6—5·9) given for millerite may be due to the presence of beyrichite. Crystals are rhombohedral, with the same forms [$(01\bar{1})$, $(21\bar{1})$, (100), (110), $(31\bar{2})$], very nearly the same axial ratio ($a : c = 1 : 0{\cdot}327707$), and the same cleavages [(110) and (100) perfect] as millerite. There is also a cleavage or separation along a $(01\bar{1})$, but only where the change to millerite has begun, it may, therefore, be due to the change in volume on alteration ; this gives the millerite a curious fibrous structure.

As the two minerals have the same empirical chemical composition and crystallographic characters, but have different densities and colour, the ready alteration of beyrichite to millerite is a paramorphic change.

Hauchecornite. This occurs at Friedrich mine (Wissen, Coblenz) associated with linnæite, and millerite. Scheibe gives the formula $(Ni, Co, Fe)_7 (S, Bi, As, Sb)_8$, this, although it is analogous to the formula of pyrrhotine, is unsatisfactory. Crystals are tetragonal, showing (111) (001), (110), (112), (100), and (101). $a : c = 1 : 1{\cdot}05215$. The angles appear to be near those of the cubic system, but the striations show the mineral to be tetragonal. Colour on fresh fractures, light bronze yellow with bright metallic lustre, on tarnished crystal faces the colour is darker. No cleavage ; fracture flat-conchoidal. H = 5 ; sp. gr. = 6·4.

Linnæite. The chemical composition of this mineral is usually given as Co_3S_4 or $(CoNi)_3S_4$, it is, however, more probably $(CoNi)_4S_5$, in which case there would be an isomorphous mixture of the polydymite molecule Ni_4S_5, and the pure Co_4S_5 ; the crystal forms, twinning, cleavage and density of linnæite and polydymite being the same. L. J. S.

Piedmontite and Scheelite in Rhyolite (G. H. Williams, *Am. J. Sc.*, *XLVI.* 1893, p. 50).—The reddish varieties of the ancient volcanic rocks of South Mountain in Pennsylvania and Maryland show, besides their colour, many signs of being rich in manganese, such as, for example, the occurrence of black oxides of manganese in clefts of the rock. The more basic and ferruginous lavas are "epidotised" in a remarkable degree; amygdules are filled with epidote, and in some places the rock itself is fairly changed to a mass of epidote. The acid rocks also contain epidote, and according to the supply of manganese, the common epidote graduates from the faintest rose tinge, through the pink of withamite to the deep carmine of piedmontite. All these varieties may occur in a single crystal; in some cases the deepest colour is at the centre, as though the growth of the epidote had continued even after the supply of manganese had ceased. There are three types of occurrence of piedmontite in these rocks.

1. *Minute Crystals in Scheelite.* Here it occurs in ovoid areas resembling old spherulites; the associated minerals are quartz and rarely hæmatite, but in the centre of the cavity is usually a white vitreous mineral, which proves to be scheelite, into which the terminations of the minute piedmontite needles project.

2. *Radiating aggregates filling veins.* The mineral here forms spherulitic aggregates of needles with no trace of crystal form. Some of the needles show in their pleochroism a complex twinning structure. These radiating aggregates are minutely intergrown with clear quartz. The analysis gave 2·41 % of Ce_2O_3 and other rare earths. This piedmontite may therefore be considered as a connecting link between the three members of the epidote group. The rare earths indicating the presence of the orthite molecule, and the presence of both manganous and manganic oxides gives the mineral a position intermediate between true piedmontite and the mangan-epidote of Flink.

3. *As a microscopic constituent.* The former modes of occurrence are rare, while this is general. The groundmass of the rhyolite is full of black specks of manganese oxide, resulting from the decomposition of the piedmontite, while there is every indication that the latter mineral, as well as the associated rose and common epidote, are secondary. The piedmontite occurs in veins in the porphyritic felspars and in the groundmass, or in isolated patches; it is usually associated with secondary quartz, and is sometimes surrounded by a zone of granular epidote.

L. J. S.

Mackintoshite (W. E. Hidden and W. F. Hillebrand, *Am. J. Sc.*, *XLVI.* Aug. 1893, p. 98).—Thorogummite from Llano County, Texas, has been previously described (*Am. J. Sc.* 1889) as an alteration product containing irregular cores of a dark brown translucent mineral. The latter, from which the thorogummite has evidently been derived, has now been found in larger quantity in the same locality, embedded in cyrtolite and associated with fergusonite. This mineral is opaque and black, strongly resembling the cyrtolite in appearance. H. about 5·5; sp. gr. 5·43; no cleavage; fracture minute sub-conchoidal to hackly. The crystals are tetragonal, only show prism and pyramid faces, and closely resemble zircon and thorite in habit and angle; also massive. Before the blowpipe it is infusible. Sulphuric acid causes it to gelatinise, while it is readily soluble in a mixture of sulphuric and nitric acids. Analysis gives as the important constituents:—

SiO_2	...	..	18·90
UO_3	...	...	22·40
ThO_2	...	...	45·80
H_2O	...	...	5·81

There are also present La and Ce groups, PbO, FeO, CaO, MgO, K_2O, Na_2O, Li_2O, P_2O_5. About one fourth of the thoria is replaced by other bases.

The analysis agrees closely with that of thorogummite, the only practical difference being that in the latter the uranium exists as UO_3, the iron as Fe_2O_3, and there is more water, as would be expected in an alteration product. The composition of thorogummite is well expressed by $3SiO_2.UO_3.3ThO_2.6H_2O$, and $3SiO_2.UO_3.3ThO_2.3H_2O$. very probably represents the formula of the new mineral.

That an anhydrous form occurs in nature, as is thought true of thorite, seems probable; this would be $3SiO_2.UO_3.3ThO_2$. L. J. S.

Cordierite in an eruptive rock from South Africa.—G. A. F. Molengraaff (*Neues Jahrbuch*, 1894 (1), 79) describes a cordierite-bearing rock, specimens of which were found in the Cornelis river not far from Harrismith, in the Orange River Free State.

Macroscopically the rock is deep black with the greasy lustre characteristic of vitreous rocks. Its sp. gr. is 2·458. Under the microscope it is seen to consist of a homogeneous light-brownish glass in which are distributed small crystals of spinel and cordierite and numerous skeleton crystals of augite. The small crystals of cordierite have the form of hexagonal columns, and are bounded by the faces (001), (110), and (010).

They are penetration twins, having a face of {110} as twin plane and plane of composition.

In chemical constitution the rock corresponds very closely with the cordierite-bearing mica-andesite from Hoyazo, Cabo de Gata, described by A. Osann (*Zeitschr. der deutschen geol. Ges.* XL. (1888), 701). With a high silica percentage (64·54) and fairly high percentage of iron and magnesia, it is very poor in alkalies (1·7 %). The glassy base must therefore be very rich in silica. As regards the genesis of the rock, the author passes in review the various recorded occurrences of cordierite in eruptive rocks, and concludes that the present rock is probably a portion of an intrusive diabase or melaphyre which has been altered by the complete fusion of fragments of foreign rocks and recrystallisation of the contact minerals spinel and cordierite. G. T. P.

Crystals of Monticellite in Slag (W. von Gümbel, *Zeitschrift für Krystallographie*, *XXII.* 1893, p. 269).—At Freihung, Oberpfalz, Bavaria, lead ores (principally galena, with some cerussite and secondary pyromorphite) occur disseminated in variegated keuper sandstones. After being separated from sandy and clayey matter, the ore is treated in a Pilz furnace. The slowly cooled slag contains well-formed, needle-shaped crystals, which give on analysis :

SiO_2	...	...	33·04
Al_2O_3	...	...	1·10
Fe_2O_3	...	...	7·91
FeO	...	...	31·53
MnO	...	...	1·16
CaO	...	...	23·52
MgO	...	...	1·18
K_2O	...	...	0·58
Na_2O	...	...	0·24
P_2O_5	...	...	0·31
			100·57

This corresponds to the formula SiO_4CaFe. Sp. gr. = 3·580.

The clear greyish-green crystals show the forms $q\{021\}$, $n\{110\}$, $b\{010\}$, and are elongated in the direction of the a axis.

The mean of eight crystals gave :

$$a : b : c = 0{\cdot}4885 : 1 : 0{\cdot}5769.$$

The parameters are very near those of monticellite. The substance is therefore monticellite with FeO in place of MgO. L. J. S.

Artificial production of Ægirine (Helge Bäckström, *Bull. Soc. Fr. Min. XVI.* 1893, p. 130).—After fusion, felspathic phonolites were slowly cooled for three days. Thin slices of the product showed many felspar microliths with small extinction angles, also nepheline, colourless pyroxene microliths with high extinction, octahedra of picotite, and needle-shaped microliths, probably of olivine. Leucite phonolites, rich in haüyne, treated in the same way, showed oligoclase and nepheline, and very many yellow pyroxene crystals. The latter agree in their optical characters with a pyroxene near to ægirine; the dispersion is very marked, so that in white light there is no definite extinction, but a bluish tint, passing into brownish, as in the titaniferous pyroxenes of basic rocks rich in alkalies.

In these experiments sanidine was not produced.

A mixture of quartz, ferric oxide and sodium carbonate, in the proportions given by the formula of ægirine, treated as above, gave a mass largely consisting of prismatic crystals of ægirine, also some yellow glass, hæmatite scales, and some needles of earlier formation than the ægirine, which were probably felspar. L. J. S.

Artificial production of Rutile (M. L. Michel, *Bull. Soc. Fr. Min. XVI.* 1893, p. 37).—In a previous paper melanite and sphene were described as being produced by heating a mixture of ilmenite, sulphide of calcium, silica, and carbon. The present paper gives the result of heating a mixture of two and a half parts of iron pyrites and one of ilmenite to a temperature of about 1,200° for several hours. The resulting mass consisted of pyrrhotine with numerous cavities, on the walls of which were crystals of rutile. The crystals have the forms m {110} and a {100}, and are elongated parallel to the vertical axis; they are of a very dark blue colour, and have a high adamantine lustre. Hardness = 6, density 4·28. Analysis gives 99·14 % TiO_2, and traces of sulphide of iron. The crystals are very similar to Madagascar specimens. When heated in an atmosphere of oxygen the blue colour changes to reddish.

The *pyrrhotine* is in crystalline masses of lamellar texture of a bronze yellow colour, slightly magnetic; hardness 4; density 4·5; composition Fe_8S_9. L. J. S.

The rhyolites of Iceland. H. Bäckström in his Inaugural Dissertation, *Beitr. z. Kennt. der isländischen Liparite* (Stockholm 1892) gives some interesting results respecting the liparites (rhyolites) of the classic volcanic area of Iceland. These rocks, though far inferior in extent to the basalts of the same country, have already received attention from a

number of geologists. The material on which the author has made a petrographical study and a number of careful chemical analyses, includes some of the latest (post-glacial) lavas (I.-IV.) from the district east of Hecla, differing in some respects from most of the earlier flows V.-VIII.). Taken as a whole, the rocks are in part volcanic glasses (obsidian), in part stony rhyolites, often micropegmatitic. Their mineral constitution is simple, giving for the most part only felspar, pyroxene, iron-ores and zircon, with unindividualised glassy matter. Among the porphyritic crystals quartz is scarcely met with, and sanidine is at least very subordinate to the plagioclase felspar. Biotite and hornblende are almost wholly wanting in the rocks, the ferro-magnesian minerals being represented by a pyroxene of the diopside group, poor in iron. The granules of iron-ore are in part titaniferous. Little well-formed crystals of zircon are enclosed in the porphyritic felspars. [In almost all these features the Icelandic rhyolites show a striking similarity to the Ordovician lavas of Caernarvonshire.] Some of the rocks approach the trachytes in character and composition (III. and VII.); others come near the dacites (VIII.); but the author considers that no true intermediate rocks are known in Iceland.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
SiO_2	69·70	69·81	62·72	67·91	72·15	73·81	66·55	73·40
TiO_2	0·38	1·06	1·06	0·53	0·45	0·97	0·66	0·43
Al_2O_3	14·78	13·85	15·69	15·17	13·50	13·72	16·35	12·90
Fe_2O_3	2·98	3·21	5·25	3·92	3·12	1·59	4·00	3·70
MgO	0·59	0·43	1·34	0·55	0·16	0·23	0·38	0·14
CaO	1·07	1·38	3·33	1·59	0·93	0·61	1·34	2·35
Na_2O	4·77	5·56	5·45	5·36	4·20	5·29	5·40	3·83
K_2O	4·45	4·40	4·19	4·52	4·54	4·09	4·97	2·99
H_2O	—	—	—	—	0·85	—	0·40	0·43
	98·72	99·70	99·03	99·55	99·90	100·31	100·05	100·17

The great predominance of basaltic over rhyolitic lavas is regarded as a characteristic of the "petrographical province" of which Iceland is the centre, extending from Scotland and the north of Ireland far into the Arctic regions. The rhyolites are finally compared with those of the "Great Basin" in the western states of America and Hungary—Transylvania region. In both these areas rhyolites largely predominate over basalts, and the dominant alkali is potash; the acid lavas of Iceland, on the other hand, are soda-rhyolites. A. H.

The Elæolite-syenite of Litchfield, Maine. Chemical analyses of a number of associated minerals and of the rock which they compose have always a special interest. Such a collection of analyses is given by W. S. Bayley for the well-known elæolite-syenite of Litchfield. The rock is remarkable for the absence of hornblende, pyroxene and sphene, and for the predominance of albite among the felspathic constituents.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
SiO_2	60·39	68·28	65·14	43·74	37·33	37·22	32·35	35·26
ZrO_2	—	—	—	—	—	—	—	63·33
Al_2O_3	22·51	19·62	18·19	34·48	31·87	28·32	17·47	—
Fe_2O_3	0·42	—	—	—	—	tr.	24·22	0·79
FeO	2·26	0·23	0·25	—	—	—	13·11	—
MnO	0·08	—	—	—	—	(Mn_2O_3 tr.)	1·02	—
MgO	0·13	0·09	0·16	trace	—	0·07	—	—
CaO	0·32	0·31	0·33	trace	—	4·40	0·89	—
Na_2O	8·44	10·81	1·68	16·62	24·56	19·43	6·40	—
K_2O	4·77	0·39	14·14	4·55	0·10	0·18	0·70	—
H_2O	0·57	0·09	0·17	0·86	1·07	3·86	4·67	—
CO_2	trace	—	—	—	—	6 22	—	—
Cl	—	—	—	—	6·83*	—	—	—
	99·95	99·82	100·06	100·25	100·22*	99·70	100·83	99·74†

Column I. gives the bulk-analysis of the rock (L. G. Eakins): II. the albite, sp. gr. 2·622, and III. the orthoclase and microcline, sp. gr. 2·56 (both by W. H. Melville): IV. the elæolite: V. the sodalite, * oxygen corresponding to chlorine deducted from total: VI. the cancrinite, and VII. the lepidomelane (all by F. W. Clarke): VIII. the zircon, †with 0·36 undetermined (Gibbs). The bulk-analysis I. corresponds nearly to 47 per cent. of albite, 27 of potash-felspars, 17 of elæolite, 7 of lepidomelane and 2 of cancrinite. A. H.

An augite-granite from Minnesota. An interesting granite is described by U. S. Grant, from Kekequabic Lake, a little south of the International boundary (*Amer. Geol.* Vol. xi. p. 383, 1893). Its analysis (I) shows it to be a soda-granite of only moderately acid character: locally it assumes a porphyritic facies, but the composition of this variety (II.) does not differ essentially from that of the normal type. The dominant felspar has a specific gravity 2·59 to 2·60, and its analysis (III.) shows that it is an anorthoclase of approximate constitution $Or_5Ab_{14}An_1$. Quartz occurs only sparingly. The augite (analysis IV.) is a soda-bearing variety

containing about 21 per cent. of the acmite-molecule. It builds idiomorphic crystals of varying shades of green with slight pleochroism, and zonary structure, the colourless interior giving an extinction-angle of 40°, and the green outer rim about 25°; its specific gravity is 3. The other minerals of the rock are secondary hornblende, a little biotite and apatite.

	I.	II.	III.	IV.	V.	VI.
SiO_2	66·84	67·42	67·99	53·19	12·35 (TiO_2·12)	1·16
Al_2O_3	18·22	15·88	19·27	2·38	·10	1·81
Fe_2O_3	2·27	1·37	0·82	9·25	58·68	69·08
FeO	0·20	1·14	—	5·15	21·34(MnO 1·22)	27·10 (·33)
MgO	0·81	1·13	0·02	9·43	4·08	·25
CaO	3·31	3·49	0·75	17·81	1·91	·53
Na_2O	5·14	6·42	6·23	2·63	trace	—
K_2O	2·80	2·65	3·05	0·38	—	—
H_2O	0·46	0·05	0·90	0·01	·19 (loss)	—
P_2O_5	trace	0·07	—	—	·25	·06
	100·05	99·92	99·03	100·23	100·24	100·32

A. H.

Actinolite-magnetite-schists in Minnesota. W. S. Bayley describes some curious crystalline schists from the iron-bearing formations of the Mesabe range (*Amer. Journ. Sc.* Vol. xlvi. p. 176, 1893). The rocks consist of from 50 to 90 per cent. of magnetite (mostly free from titanium), the only other important constituent being an amphibole, apparently actinolite, though grünerite may also be represented. The magnetite is in idiomorphic crystals, the amphibole in interlocking crystal-plates and bundles of fibres. Column V. above shows the analysis of a typical example, and VI. that of one in which magnetite largely predominates. Except for the absence of hæmatite and rarity of quartz, the rocks closely resemble those described by Irving and Van Hise, from the Penokee series of Michigan and Wisconsin. A. H.

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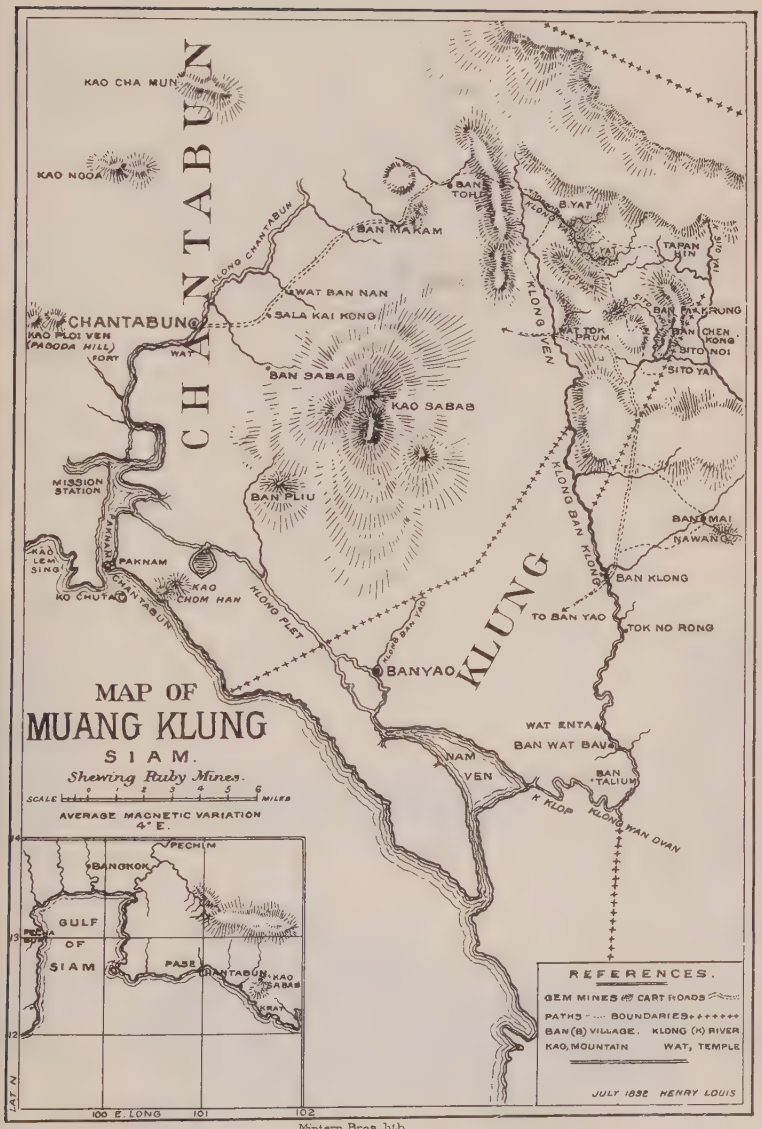

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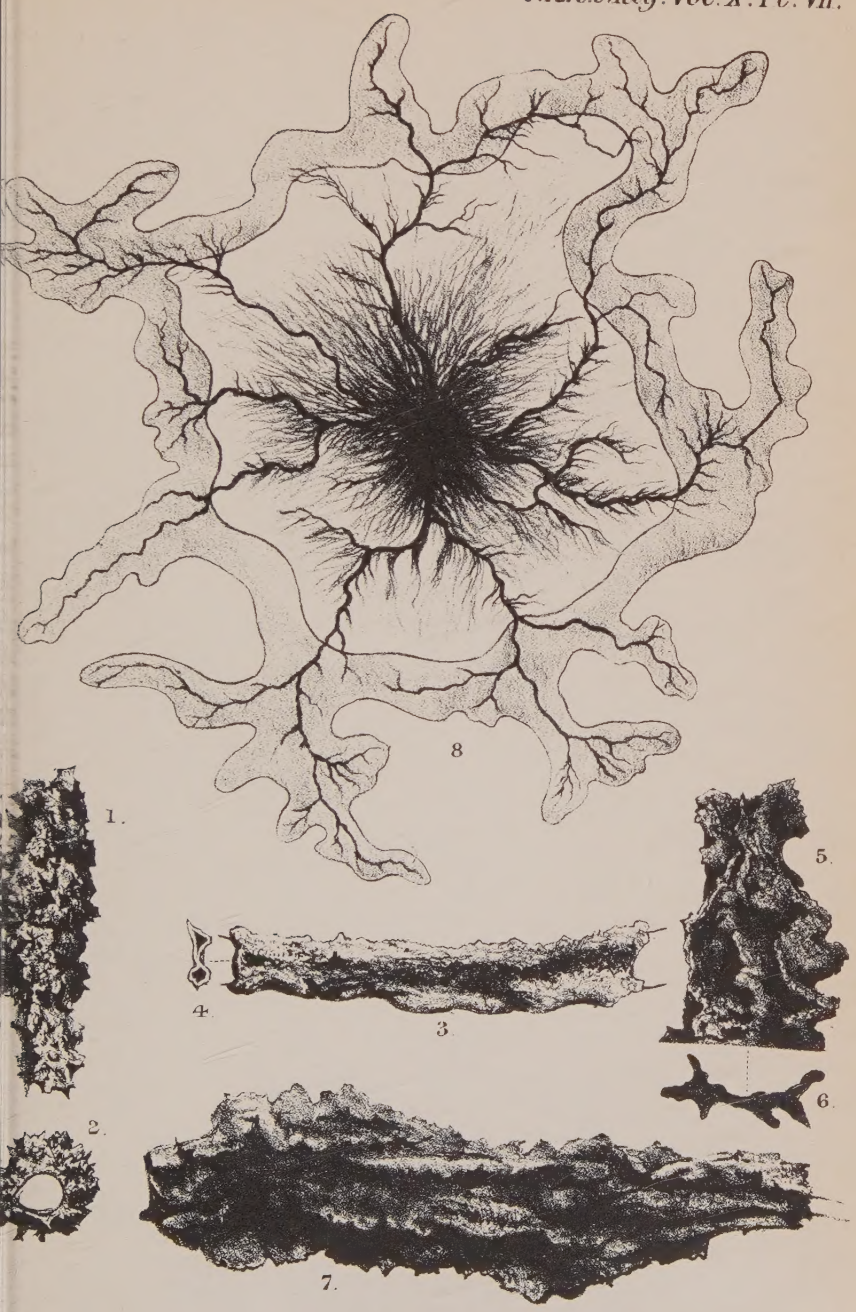

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FIGS 1–7. FULGURITES FROM GRIQUALAND WEST.

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